

Dr. Albert Haller's *R*
PHYSIOLOGY;

BEING A
COURSE of LECTURES
UPON THE
VISCERAL ANATOMY and VITAL
OECONOMY of HUMAN BODIES:

INCLUDING

The latest and most considerable DISCOVERIES and
IMPROVEMENTS, which have been made by the
most eminent Professors, through all Parts of
EUROPE, down to the present Year.

Compiled for the Use of the UNIVERSITY of GOTTIN-
GEN; now illustrated with useful *Remarks*; with an
History of Medicine; and with a *Nosology*, or Doctrine
of Diseases.

IN TWO VOLUMES.

VOL. I.

L O N D O N:

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Benigno Scrutinio
Celeberrimi Archiatri
ALBERTI ab HALLER
Egregii hujus operis auctoris;
Regiæ Majestatis Britannicæ
Electoralis Hannoveriensis
Consilarii Aulici, & Archiatri:
in
Academiâ Gottingæ florentissimâ
Medicinæ, Anatomix, Chirurgiæ,
Botanicesque Professoris publici, ordinarii, Ejus-
demque Chirurgorum Collegii Præsidis
in
Academiâ Curiosorum Imperiali,
Etiamque in
Societatibus Scientiarum Regiis
Borussicæ, Gottingæ, Sweticæ, Upsalicæ,
Parisiensi, Londinensi, &c.
Consocii plurimum venerandi;
nec non
In supremo Senatu Reipublicæ
BERNENSIS
Ducentum Viri:
in
Omnibus Linguis Europæanis
Lectissimi,
Nostræque Anglorum Peritissimi;

[iv]

Omnibus

In Litteris Humanioribus, Scientiisque
Callentissimi ;
fed

In amplissima Facultate propria, ubique & fere
ad miraculum

Perdocti :

H Æ C

In linguam Britanniae vernaculam egregii sui
Operis conversi

EDITIO,

Humilimè offertur,

D. D. D.

Servo suo addictissimo

SAMUELE MIHLES

Academiæ Glasguensis Doctore Medico

Collegiique Regii Medicorum Londinensium

Diplomate Permissio.



T O T H E

R E A D E R.

ALL faculties, arts and sciences, are allowed by the ablest judges to be unavoidably subject to such changes by time and after-improvements, as plainly render a new digest or system of them equally useful and necessary, once at least within a quarter of an age: and it would be well if our many annual abortives, that serve chiefly to perplex beginners, or banish better systems, could within these bounds be restrained. The space prescribed, has indeed twice elapsed since the appearance of such a digest, from under the quill of the ingenious Dr. James Keill, and that of Dr. Drake; and it is now near a fourth of an age since the lectures of our great Dr. Boerhaave, were by him collected: all which performances being drawn by masterly pencils, were indeed excellent for their day, and such only as can pretend to share any competition with the present system. A reading of Dr. Boerhaave's lectures, formerly published by our author in Latin, and by ourselves in English, may conduce to explain many particulars more largely to weaker capacities than could be done within this compass; but those who are tolerably read in the faculty, may learn hence
not

not only the sum and substance of those more voluminous lectures, but also numberless important and useful discoveries, made within the fourth of an age past, since those lectures were closed; communicated to the public by our learned author, and other eminent professors in several parts of Europe. To render our author's sense just and plain, has often required more words than occur in the original; but 'tis more eligible to be well understood in two or three words, than to be doubtful or obscure in one. We have also taken the liberty to insert a number of considerable remarks, either philosophical or practical, as our own observations suggested them in the course of our version; which with the History and Nosology, have indeed somewhat increased the bulk and price of the system, but neither, we hope, beyond proportionable measures of useful instruction and practical utility: at least our views in the whole were only to employ our leisure hours in recommending the best means we know, to the hands of those who desire to gain a true and useful knowledge of their profession, in the most plain, just, and easy manner.

S. M.

CON-

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A N

HISTORICAL INTRODUCTION

Concerning the

ORIGIN and PROGRESS

O F

PHYSIOLOGY and MEDICINE.

§. I. **I**T will be readily allowed by the wiser part of the world, that the trite platonic adage, advising man to a knowledge of himself (*γνῶθι σεαυτὸν*) strikes more at the priest and physician, than the rest of society; since the latter is obliged to carry his disquisitions much deeper than the curious painter or statuary, even to the innermost organizations and actions of each part, as far as armed sense and sound reason will conduct him; in order to understand, or explain, every change and appearance resulting from the body only, or from the body and mind conjunctly, whether in a healthy or a diseased state: while the former, less concerned about the organizations of the body, or its mutual connexions with the mind, advances much higher by the scale of natural and revealed truth, in determining the

religious and moral state of them both, either for the present or the future. Man then, is one divisible essence, compounded of animal body and intellectual soul; yet so that his identity or personality resides in the last, as the superior part, which is however incomplete, without a duly disposed and organised body, as the medium of all her operations in life. It is enough, that we know she is, because she operates, thinks, and reasons; and that she always will be, because she is immaterial, therefore unextended, and has no power not to be. As for the operations of the soul, after she is separated from the body by death, they must be purely intellectual; like those of angels or spirits, and consequently such as we can have no notion of while she is connected to body, without whose medium we can naturally have no perceptions, either of ourselves or of an external world *.

§. II. Our body then, in its primitive state, is gradually built up, from gelatinous or slimy fluids, shooting out first into cob-web-like threads and plains, whereof the most part are by degrees moulded into two springs, which like those of a watch, we shall distinguish into (1.) the *heart* and sanguiferous system, as the fusee or main spring; and (2.) the *encephalon*, and appended nervous system, as the pendu-

* [Aristot. 1. de part. anim. 5. & Cicero 1. Tusc. question.] Anima sit animus, ignisve, nescio: nec me pudet nescire quod nesciam.—non videtur, sed ex functionibus deprehenditur [Apuleius de mundo]: eamque immortalem esse, & ab interitu liberam [Plato, 10. de repub.] Morte caret animæ [Ovid. 15. Metam.]

lum-spring, or regulator. To these two springs there are subservient, a set of corresponding hydraulic wheels, or intermediate systematical organs, called viscera, glands, &c. serving either to the faculty of nutrition, sensation, motion, or procreation, in their most extensive latitudes: all which are moved or actuated by a sort of endless or circular chain of globular and albuminous juices, intermixed all together in the heart and arteries; thence separated into various sorts and consistencies, in different parts, and returned again (so much as are sound of them) into commixture as at first, while the morbid or unsound parts are thrown off by certain emunctories or out-lets. And this is the most contracted or aggregated view that can be had of the human body, at once, considered as an animated and hydraulic automaton.

§. III. It is therefore from the superb and so much admired fabric of our body, as the immediate residence and interpreter of an immortal soul, that medicine properly begins to draw the first lines of her ample landscape: for physic has been allowed by the wise men of all ages to begin where philosophy ends; and they have equally granted, that all the lines of wide philosophy center in him, whose animal body is both the head and epitome of the whole terraqueous world*; to travel through and graphically describe the numberless regions of

* Unde Porphyr. de vita Pythag. ὁ ἀνθρώπος μικρὸς κόσμος. V. Psal. viii. 6. & Cicero. I. de legibus. Quasi autem non dicam in homine: sed in omni cælo atque terra ratione divinitus.

which, under health and disease, is the proper object of medicine. But here we often caress and admire the despicable matter, instead of the infinitely wise form given to it by the signet of omnipotency; for if we do but reflect either upon its mucaginous origination, in the first months of pregnancy, before it has any ability to converse with the soul, or upon its putrilaginous dissolution into an abominable vapour (into which a very few days of splendant sun, in a hot climate, will wholly convert it, except the skeleton of bones) after it is thrown off, like a worn-out garment, from the celestial inhabitant; we shall rather quit the matter for the form, and even make that only a step to look up after the adorable signet, which first gave the admirable impression.

§. IV. Our primitive ancestors, not yet acquainted with those luxuries and abuses of natural benefits, which were afterwards so much cultivated, and are now spread to the prejudice of human perfection throughout the world, lived contentedly on the tender roots and plants, of their own and nature's tillage, joined with the mealy pulses or grain of the field, and enriched by oily and succulent fruits of the tree and bush *. The simplicity of their archi-

* Gen. c. i. v. 29. & Cic. de nat. deor. & Offic. lib. 1. *Quæ in terra gignuntur, ad usus hominum omnia creavit.—Terra enim sæta frugibus, & vario leguminum genere quæ maxima largitate fundit ea ferarumne an hominum causa gignere videtur? Quid de vitibus olivetisque dicam.—Canum fide custodia, tamque amans dominorum adulatio? Quid de bobus quorum terga ad onus; cervices ad jugum? &c.*

texture, both as to cloathing and habitation, equalled that of their diet. A warm skin wrapped about their waist and shoulders, with another upon stubble, for their couch; a natural grot or cavern, sheltered by an agreeable thicket, and bordering upon a refreshing spring or rivulet, compleated the retinue of their apparel, and the grandeur of their hôtel. They bestowed their pride, envy, and intemperance in labouring the earth, in training their flock, instructing their children, and providing a little dinner or supper for themselves and cattle; which, next to their religious obligations, it was the height of their ambition to see safe and sound, sleeping round them at night. This simplicity of life made them healthy, and even hardened to a proof, against the inclemencies of air, aliments, and most distempers that now afflict the puny race of mankind; but could not secure them from wounds, bruises, burns, fractures, dislocations, and other accidents that so earnestly call for chirurgical aid.

§. V. Therefore as surgery, out of necessity, became the earliest as well as the most sensible part of medicine; so anatomy, for the same reasons, always followed close to her heels: and both were obliged to make some figure in the world, before the skill of physicians could be called to the bar of practice. There is no room to doubt, but our first fathers were so wise and void of superstition, that if they happened to break a bone, or dislocate a joint, they had a ready recourse to the next dormitory or tomb, and consulted the figures or connections

of the bones, to relieve themselves; in the same manner as pain and necessity would instantly oblige them to try various substances for the relief of burns, wounds, &c. For these endeavours for relief, we see now naturally exerted in every injured person, who knows nothing either of physic or surgery. The necessity which dependents are under, to consult their superiors, for relief in all cases of distress, made the oldest patriarchs, priests, and princes, the wisest anatomists, no less than the ablest surgeons and physicians. Some of these, who were oftener called upon for help, invited by a natural curiosity, no less than a desire of being useful, and caressed with the honours or rewards that attend on gratuity, doubtless took into his custody the first natural skeleton, either of man or beast, that fell in his way, cleansed by the returning dews or rains, and dissected or dried by the dissolving rays of the sun. Thus began the earliest, and the easiest part of anatomy, osteology; which, with the situations of the ligaments, joints, nerves, tendons, and larger external blood-vessels, made one of the most useful and necessary branches of princely learning; to be employed in the murdering wars; that ever plagued mankind from the first offspring of Adam. Thus the art of healing, as yet chiefly surgical, and raised from repeated practices on the victims of inclement wars, or unavoidable accidents, was for many years lodged in the hands of a few elders, priests, and school-men, among the Hebrews and contiguous nations of the east; who taught it traditionally

ditionally as a most useful branch of philosophy, from the father or master to the son or engaged pupil (παιδευμῆνοι): from which last a filial obedience and perpetual gratitude were ever solemnly enjoined and expected; since the birth in arts, sciences, and learning, appeared even of superior value to that of nature. Examples of this are hereafter notable in the munificence of great Alexander, to his preceptor Aristotle; in the oath of allegiance prescribed by Hippocrates to his pupils, &c.

§. VI. Soon after the flood the art of healing seems to have extended, together with monarchy, near Mesopotamia, under Phœbus king of Assyria; whence it spread with arts and languages into Ægypt and Chaldea. For it appears by the chronographical monuments wrote concerning the affairs of Ægypt, by order of king Ptolemy Philadelphus, under the care of the learned Manethus, of the sacerdotal order, transcribed and handed down to us by the trusty Syncellus [of the eighth century, in his Greek history of the dynasties of the kings of Ægypt, in whose antiquities he appears greatly to have rivalled both Herodotus and Diodorus Siculus (pag. 54. and 56. cap. 6.) “ That Mercurius, “ first king of the Thebans, among other “ things, wrote books or skins upon anatomy; “ for he was a physician.” Φερονται βιβλοι ανατομικαι ιατρικαι γαρ ην &c. The same is also confirmed to us by Clemens Alexandrinus, of equal credit, and near six ages older than Syncellus; who tells us (Stromat. lib. i. p. 634. b.). “ That out of forty two dissertations left by

“ Mercurius, six of them appertained to the
 “ philosophy of the Ægyptians; and the other
 “ six related to the art of healing, of which
 “ the first was anatomical, *upon the construction*
 “ *of the human body.*” περίτῆς τῆ σώματος κα-
 τασκευῆς. It is therefore not without reason,
 said by Pliny (l. 29. c. 2.), that the Ægyptians
 claim physic as an art invented amongst them.
 For this Mercurius flourished soon after the
 death of Noah (Gen. ix. 28.), a whole thousand
 years before the Æsculapian inventor of the
 Greeks (whose son Machon, is by Homer
 (Il. B.) mentioned at the sackage of Troy);
 fifteen ages before the times of Hippocrates, and
 near twenty before the days of Galen.

§. VII. It is not to be wondered, that Mer-
 curius Ægyptiacus should have been so early
 able to leave several volumina or skins upon
 anatomy in the temple of Memphis; if we
 consider the opportunities those had of know-
 ledge in the subject, who were often both pa-
 triarch, priest, and king, as well as physician
 to their subjects. For under those characters,
 there were many ample fountains laid open to
 them; such as (1.) the orthotomia, or just
 manner of slaying, cutting, and preparing ani-
 mals for sacrifice, taught by God to our first
 parents, and required by him from their suc-
 cessors, who learned it traditionally before Mo-
 ses, and afterwards by præscript, till at length the
 crucifixion of our Saviour set the emblem of him
 aside (Gen. c. iv. v. 4.). For it is not to be
 supposed, but Cain and Abel were fully in-
 structed by their father in all points required to

a just administration of sacrifice; otherwise God would not have refused to take by fire from heaven the offering of the former, for offending him by a wilful concupiscence, in not sacrificing the best of his produce; for which, and maliciously murdering his brother, as God's favourite, and a type of our Saviour; he Cain was cut off from the family of Adam, as a type of the unbelieving Jews, and destined to be accidentally shot from Lamech (Gen. iv. 23.).---(2.) From the superstitious and slowly-dreaming inspections of the internal parts of animals sacrificed to idols by Gentiles; which was probably a very early corruption made by some of the descendants of Noah.---(3.) From the dextrous killing, cutting-up, and displaying to advantage the several parts of large animals, by the art of butchery; which soon became a profession, after a licence was given by God for men to eat flesh, in the days of Noah (Gen. ix. 4.).---(4.) From the care which all princes and great men took to have their predecessors accurately embalmed; which must have been executed with very great exactness, since we are told (Gen. l. 2. and 3.) in the original, that several physicians were employed forty days in embalming Jacob Israel; and that this was the usual time for them to be employed in such a work *.---And lastly, (5.) from the frequent and ample wounds that ever beset men, either accidentally or in wars: which last gave even to philosophers very just notions of anatomy, since the learned Galen himself admires and praises (de usu part. 4. 14.) the great knowledge

ledge and skill of the poet Homer, who wrote about nine or ten ages before himself, and before christianity. See several elegant flowers of anatomy in his Iliad. Lib. iv. ver. 517, & seq. Lib. v. ver. 65, & seq.---Lib. v. ver. 305, & seq.---Lib. xi. ver. 577.---Lib. xii. ver. 384. &c.

R E M A R K.

* The great recorder of antiquity, Herodotus (Euterpe. cap. 87. & 88.), who wrote his history near five ages before christianity, describes three methods of embalming in use among the Ægyptians, of which only one could be of any considerable service to anatomy; which we shall therefore describe, without presuming to determine whether it be the same with that practised upon Jacob, Joseph (Gen. l. ver. 2. & 3.---ib. ver. 25. ult.), and the other patriarchs, or not. “ First the director, “ having laid out the body, and marked how far “ the cutter was to open the left side; this last extracted the brain through the nostrils, and cut “ throw the marked side with an Ægyptian “ pebble: which being effected, he immediately “ took to his heels; because thereupon it was “ customary for those present to curse him, and “ through stones after him. Next came those “ called the curers, salters, and anointers of the “ body, as they were most esteemed in their professions; and now one of these extracted the “ guts, and other viscera of the body, except the “ heart and kidneys, through the incision that had “ been made: after this, another washed the venters with Phœnician wine, charged with perfumes; and then the body, thus washed, was “ successively anointed for the space of thirty days, “ with balsam of the cedar-tree, and other costly “ preservatives: next, the stomach and guts, “ which

“ which had been before extracted, were stuffed
 “ with myrrh, cassia-wood, and other perfumes
 “ (except incense or frankincense), and then sewed
 “ up in the body, which they now salted with
 “ nitre” [i. e. a salt of the ancients, more lixivial
 or like pot-ash than our nitre] “ for the space of
 “ seventy days, as the longest term that the body
 “ could bear the salt. This time being elapsed,
 “ the washed body is next rolled up in fine linen
 “ swaths, spread like a plaister with gums, which
 “ the Ægyptians generally use instead of glue. Be-
 “ ing thus covered to a just thickness, they make
 “ a hollow image or case of wood, correspond-
 “ ing to the dead original; which being thus in-
 “ closed, they reposit in some closet or cell of a
 “ chamber,” [or funeral dormitory] “ standing
 “ upright on its feet.”

2. Thus small, rude, and natural (n^o. 1. *supra*) was the birth of those now copious and
 mystical professions we call anatomy and medi-
 cine, seen amongst the earliest offsprings of ne-
 cessity; which latter part, medicine, had its
 first rudiments laid by (1.) accident; (2.) in-
 stinct, and (3.) promiscuous experiment.---By
accident, we mean the discovery of medicines
 undesignedly made, like what we are told by
 M. Geoffrey of the celebrated bark; viz. that a
 number of the trees being blown down into an
 adjacent lake, gave such a bitter tincture to the
 water, that no persons would use it, nor any
 cattle drink it: 'till at length an Indian, urged
 with severe thirst, in an intermittent fever, ea-
 gerly took two or three large draughts, which
 cured his distemper, and gave such repute to
 the waters, that they were soon exhausted;
 and

and when the lake, filled by the next rains, was found without its bitterness and virtues, it was concluded they both arose from the macerated trees which had been formerly blown into it, as indeed they were soon convinced by experiment.---By *instinct* we mean that discretion, which in different degrees is diffused through all animals, directing them to choose what is good, and avoid whatever is evil or destructive to them; which faculty is possessed by man in a degree far superior to the rest of the animal creation. We see the fond and familiar beast we call a dog, having a sensible membranous stomach like that of ourselves, with a much more sharp or corroding saliva and stomach juice, will naturally endeavour to allay his hungry pain by the first (even dry) bone that comes in his way, reducible to the grinding powers of his teeth, and makes it more an absorbent to acrimony, than a matter of nourishment; whence the dry chalky faces thence left, called album græcum. The same does the green-sickness-girl with slates, chalk, wall, ashes, &c. from an offending acid and debility. But if putrid flesh makes an offending alcaley on the stomach of dog or cat, they naturally fall to eating of acescent grass, &c. In fevers also, nature rejects what is bad, and generally craves for what is salutary to the distemper.---By promiscuous *experiment*, we intend remedies found by hasty or indiscriminate trials, not pointed out by slow reason or instinct; as, e. g. if a peasant cuts or burns his finger, a number of odd things (that come first

to

to hand) are immediately applied, and those which hurt or heal are accordingly remarked. In this way many valuable remedies have been first found by vulgar hands, that have come afterwards to a better use under the highest in our profession; to instance only in some late lixivial medicines for the stone or gravel, &c. In this manner, accident, instinct, and loose experiment drew some of the first lines of physic; improved afterwards by degrees into a profession, like other human arts and sciences.

3. Afterwards physic went on improving among the Greeks, in a much more sensible way, viz: (1.) by exposing their sick in the most public ways and markets *, obliging passengers to ask about their distempers, and inform them if they had known any thing serviceable in the like cases; (2.) by appointing certain persons (chiefly priests from the temples of Apollo and Æsculapius, as the most learned and able), to practise in the diseases of some one part, as the eye, ear, &c. by which such gained much wealth and honour to their families, within which they hoarded and cramped up the art; (3.) by writing down privately each their particular observations (nº. 1. supra), philosophical, anatomical, or medical; and by registering publicly the principal remedies that had been found useful, upon tables in the pillars and

* *Ægrotos suos in publico proponebant, ut prætereun-
tium quivis, si quid vel ipse eodem morbo conflictatus vel
similiter laboranti opitulatus medelæ nosset, id ægrotanti
significaret. Plutarch. lat. vivend.*

walls of those temples †, which were peculiarly dedicated to their physical deities, Apollo, and Æsculapius. A fragment of one of these Greek tables, still preserved at Rome, and published in the collections of Gruterus, runs thus:

“ Lucius being afflicted with a pain in his side,
 “ implored the assistance of the God Æsculapius;
 “ whereupon the oracle directed him
 “ to go to the altar, to take some of the ashes,
 “ mix them with wine, and apply them to the
 “ aching-side: which done, he grew well,
 “ and gave thanks to the god, and his health
 “ to the service of his country.”

Wood ashes steeped in wine would doubtless form a succedaneum to what we now call opodeltoch; and be of use to rheumatic pains of the side, or other parts. Sometimes, in cases of sterility and weakness, they were ordered to put a hatchet or some iron instrument in the cleft of a recent oak, and take the crocus or rust formed upon it by the astringent, subacid sap, &c. Thus the said temples were a sort of hospitals, to which the sick repaired for advice; which they here received, either in dreams or by ear, whenever the devil or his priests thought fit to make their disclosures; which they often did to the best of their power, in order to fix those honours and worships upon themselves, which were due only to almighty God.

4. Thus went on physic, improving in the hands of priests, and a few Greek philosophers,

* Nunc dea, nunc succurre mihi, nam posse mederi,
 picta docet templis, multa tabella tuis. Tibull. lib. I.
 eleg. 13.

which

which last had schools, chiefly physical, at Rhodes, Coos, Cnidos, and Epidaurus, where Pythagoras, Heraclitus, and Democritus were for some time teachers: but the most considerable of them was the school of Cos, in the island Coos; where Herodicus, who introduced the gymnasia or exercises into medicine, and his son, the great Hippocrates *, were educated. And this leads us to the birth or second æra of physic, which now, too perfect and formidable to be any longer confined within the womb of philosophy, loudly called for some hand to deliver her from the cramping chains and secret cabinets of select priests, philosophers, and topical practisers; that she might come freely abroad as a liberal science, to improve knowledge, and be improved herself, under no other restraints than those of invariable truth and common utility. This task then was reserved to the great Hippocrates, from whose time we date the genuine nativity of physic, in all her branches; from whence forward, to the midst of the last century, we date her puerile growth

* Æsculapius, quoniam adhuc rudem & vulgarem hanc scientiam paulo subtilius excoluit, in deorum numerum receptus est. Hujus deinde duo filii Podalarius & Machaon Bello Trojano ducem Agamemnonem sequuti non mediocrem opem commilitonibus suis attulerunt. Homer. Il. b.—Democriti autem discipulus, Hippocrates Cous, primus quidem ex omnibus memoria dignis ab studio sapientiæ disciplinam hanc separavit. Celsus in præf.—Hippocrati honores, quos Herculi, decrevit Græcia. Plin. 7. 37. Medicinam quæ à Trojanis temporibus in nocte densissima latuerat, usque ad Peloponnesiacum bellum, revocavit in lucem; & instituit hanc quæ *Clinicen* vocatur. Plin. lib. 29. b. 1.

and minority; when our British Hippocrates qualified her to plead rationally and justly in all her causes: and being now near the summit of her perfection, the present posture of affairs in the medical world, leave me in some doubt, whether we are not shortly to expect her declension.

§. VIII. The first inventor or restorer of medicine among the Greeks, is said to have been Apollo; one of whose sons or successors, *Æsculapius*, came the next to him in honours and repute, for considerably improving or enlarging the bounds of healing; which from the time that this last great professor was killed by a clap of thunder, suffered a sort of extinction or interregnum for near 500 years; 'till in the reign of the wise Persian king Artaxerxes, it was again restored, by the splendour of Hippocrates, one of the said *Asclepian* or *Æsculapian* family, in the island Coos. [*Isidorus Hispalensis*. Orig. iv. 3. 4.] He renewed the divine honours tributary to his inventive ancestors, Apollo and *Æsculapius*, by consecrating temples to their service, in which the most successful remedies for diseases were recorded: and when those temples were afterwards destroyed by fire, he with great judgment reduced his collections into a liberal system; and first instituted the clinical or bed-side practice, that has ever since been followed, instead of obliging the sick or injured to repair for help to the temples. [*Plinius secundus*, hist. nat. 29. 1.] Thus physic, invented by *Apollo*, and amplified by *Æsculapius*, was at length perfected among the Greeks,
by

by their successor *Hippocrates*; for which he had equally with his ancestors, divine honours paid to his memory, by the paganism of those days and countries: to which Celsus, his Latin imitator, four ages after, just before Christianity, under the emperor Justus, readily subscribes himself (in pref. lib. 1.); for that Hippocrates had first separated physic from polymathy, and generously communicated its precepts, reduced to a plain system, which his ancestors had concealed or restrained within their own families*.

2. Pausanius, the Grecian, who lived after Celsus at Rome, in the second age of christianity, in the tenth book of his descriptions of Greece; tells us, that among other presents to the delphic temple of Apollo, there was kept one, given by Hippocrates, and of a very great antiquity; being the figure of a man in brass, wasted even to the bones by a consumption.--- In this probably might be seen some of the earliest and justest lines of anatomy, as she had as yet appeared to the ancestors of Hippocrates.

3. This last father and glory of medicine, such, not only to his learned countrymen the Greeks, but to all more remote and less polished nations, and even to all distant ages, so long as physic herself shall subsist; was descended from the same name in the physical line, from *Æsculapius* (nº. 1. sup.) born an. mundi 3512, in the city of Cos, of the island Coos, near the Attic continent; and flourished in the adjacent countries, about five ages before the coming of our saviour. Hippocrates, like other great genuises, set out even young, in his pro-

* V. loc. citat. sub. p. xv.

feſſion; and having quickly accompliſhed his ſtudies in philology, rhetoric and logic, under Gorgias Leontius; in geometry, aſtronomy, and philoſophy, under Democritus of Abdera; and in all the branches of medicine, under his two great medical anceſtors, his grand-father Hippocrates, and his father Heraclides, who were deſcended the 14th family, in a right line from the two ſons of *Æſculapius*, *Podalirius* and *Machaon*, (mentioned as princes by Homer, at the ſackage of Troy; and after promoted, the former to be king of Caria, in the leſſer Aſia; and the latter ſovereign of Meſene, included as a peninſula betwixt the Tygris and Euphrates, in the Babilonic part of Aſia.). He ſpent ſome of his days in the academical diſcipline of medical youths, in his native city, where an *Æſculapian muſæum* had been erected by his anceſtors to teach them; for whom he preſcribed didactical aphoriſms, before he wrote his ſyſtem, and before the conflagration of the medical temples (nº. 1. ſup.); but the majority of his life was ſpent, like that of the other great phyſicians and philoſophers of thoſe times, perpetually itinerant.

4. Although he was archiater to Perdicas king of Macedon, courted and careſſed by all the greateſt kings, princes, and philoſophers of his day; yet he always appeared as the grave and plain ſophiſt, wore a ſort of cowl or capuce for the conveniency of travelling, and ſpared no labours by land or ſea, to relieve the calamities of his country. He always held ſuch a ſtrict regard for the principles of truth,

truth, honour, and the moral œconomy of his wife mistress, nature, as gave him a laudable contempt over the wealth, pleasures, and honours of the great; which, with his learned works, amicable and humane disposition to people of all ranks, have left him a glorious memory, untainted with the usual pagan corruptions. His incessant travels through all parts of Macedonia, Thrace, and Thessalia, were equally useful to his country, as entertaining and instructive to himself; because he always kept a journal, into which he transcribed all adversaria or observations that appeared worthy of notice: although this gave occasion for those who envied his great character, to suspect, and even to say, that he procured the conflagration of the public library belonging to the physic-school of Cnidos; because having thus secured its flowers, he might the better send them out to the world, as those of his own growth or culture; which was in reality a malicious calumny, for having espoused the cause of truth, in opposition to the false dogmata taught by that school, who judged every disease that occurred to be of a new kind.

5. Many of his adversaria were probably collected from the inscriptions, temples, philosophers, and physicians visited in his tours; but still the bulk must be ascribed to his own great genius and extensive practice; for by his own confession, "He never travelled or entered any house but when he had a call to succour the distressed." His magnanimity and patriot love appeared remarkably in refusing to assist Ar-

taxerxes in a plague that ravaged his army, who offered him a fee of 15,000 guineas, with other honours and advantages; but he returned for answer to his Persian majesty, that he was too rich to accept honourably any proffers that could be made from barbarians, the declared enemies to Greece. He always inculcated charity to his growing disciples, by advising them to take up with the common necessities of life, as a proper measure for their ambition; in which he set them a good example, by as readily attending the poor for nothing, as the rich for large sums. This generous disposition led him to refuse a fee of 1500 guineas from the city of Abdera, for a visit to their great philosopher and senator Democritus, suspected of madness, to whom he had been formerly a pupil in *philosophy*. Macrobius says of him, that he could neither deceive, nor be deceived. His charity gained him from every body the love of a father; and his merits raised him more than all the honours that are due to mortal man. The people of Argos erected a statue of gold to his memory; and those of Athens ordered for him crowns of the same metal. The two greatest men of the succeeding age, Plato and Aristotle, proposed him as a pattern to form themselves by; and Aristotle chose his stile to be a rule for his writings; which has made him more concise and methodical than Plato.

6. But at length, in a very advanced age, the great Hippocrates himself was crushed in Thessalia, by the jaws of the common devourer, from whom he had rescued multitudes; and

and was entombed with due honours in the way betwixt Lariffa and Gortona. Every where, for a long time after his death, Hippocrates had idol sacrifices offered to him; even much against his natural inclinations, which declared for no other sacrifice than that of diligent study in his writings, and a careful tryal of their truth and reasonableness in practice. What a pagan physician writes to his friend Eucrates, is remarkable to this purpose. I have, says he, a brazen Hippocrates, of near a cubit in length, who when the lamp before him is out, takes a tour all round my house, rattling and rummaging over all my boxes, mixing or jumbling together my medicines, throwing open my doors, &c. and this, more especially if we delay the annual sacrifice that is usually made to him. I must therefore declare that Hippocrates the physician still requires sacrifice, and is highly displeased at neglecting the festivals of divine worship to him, when the stated season returns: but he takes it kindly enough to be a guest in the feasting, to have his head crowned, and a libation of wine or mead poured out to him.---For the principal parts of this life of Hippocrates, we are beholden to the learned *Sieur A. Dacier* [in his elegant version of several of the most useful books of Hippocrates: entitled *OEuvres d'Hippocrates. &c. 12°. Par.*]. But his writings we shall mention more particularly hereafter.

§. 9. The works of Hippocrates are indeed as much superior in point of merit, as they are prior in point of time to those of his kinsman

Ariſtotle ; who was born near a quarter of an age after his deceased ancestor, and illustrious pattern to him for learning, ant. Christ. an. 384 : being the son of Nichomachus, physician to the great Alexander's grand-father, Amintas ; and directly descended in the *Æſculapian* line. But *Ariſtotle* being left early an orphan, the appetites of his youth misſed him from his studies, and soon squandered his estate, which obliged him to take the military character ; but that ill ſuiting his genius, was soon relinquished to renew the pursuit of his philosophical studies at Athens, where he is said to have been under Plato from the age of 18 to 37 ; during which time good part of his living was gained by vending perfumes, and medical nostrums, his patrimony being now entirely exhausted. Here, laying aside all indulgencies for that of close study, with eating little, and sleeping less, he soon got a-head of the Platonic school ; and gained himself a reputation, that after the decease of Plato, reached the ear of king Philip of Macedon, who made him præceptor to his son, the great Alexander, then about 14 ; whose education, in all parts of polymathy, *Ariſtotle* compleated in about eight years. Being afterwards suspected of partaking in a conspiracy against his young master, all favours ceased from that quarter, and obliged him to return to the *lycæum* or schools of Athens, which were now given to him by the magistrates, that he might fill the chair of the deceased Plato, to which he soon had a famous concourse of students. After this, the displeasures of Alexander wore off,

off, and by degrees turned into munificent presents and assistances, that greatly conduced to the perfection of philosophy, and the completion of Aristotle's ample works; which have been since made the standard of philosophy, through all ages, as those of Hippocrates were for physic, until the beginning of the last century, when the face of both received a prodigious metamorphosis for the better, by a discovery of the circulation, and a chain of improvements in mechanical knowledge. The works of Aristotle were left at his death to his disciple Theophrastus, with a charge never to publish them. The executors of Theophrastus buried them under ground, and after they had so lain near a couple of ages, they were found diversely, bought and sold, and in great danger of perishing, until Andronicus of Rhodes, a little before the appearance of christianity, got them fair copied, and disposed in good order; from which time, the doctrines of Aristotle flourished, and gradually spread at Rome, under all the Cæsars, and several of their successors. The church, indeed, at first suspected them of too much libertinism, until St. Jerom, and St. Augustin, cleared them of it. In the sixth age, Boëtius turned him into Latin; and in the eighth century, Damascen commented him, and reduced him to an abridgment. In the dawn of the 13th age, his works being abused to countenance wicked opinions, caused the church to suppress them, until they were again approved and restored to the universities of Europe by pope Urban V. in 1366, and Nico-

las V. in 1448. since when they have reigned universally, down to the middle of the last century.

2. Under the reign of the great Alexander, when all branches of polymathy were taught by the same præceptor, and in tolerable perfection; his wise tutor Aristotle seems to have first made an offset of philosophy, from the other branches of the great polymathic tree, and likewise to have made a partition betwixt philosophy and philology; as Hippocrates had a few years before made a division of physic from them both. Pliny tells (lib. 8. c. 16.), that at one time the munificent gratitude of Alexander to his wise master, devoted several thousand persons to his services in natural history, and to the forwarding his voluminous works of philosophy; together with a sum, which (according to Athenæus Deipnosophistus, lib. 9. c. 13.) appears indeed prodigious, in respect to the rate of money at that day; viz. 800 talents, equal to about 500,000 crowns sterling. The last author therefore observes, it is no wonder that Aristotle should be able to raise fifty volumes, upon the history of animals, from so ample a fund of wealth, with the observations and helps of so many correspondents, throughout all the regions of Asia and Greece. Whatever advantages Aristotle might make of anatomical fragments from his predecessors (particularly Alcmaeon, Empedocles, or even Democritus, and Hippocrates himself, who were but a few years before him), of which, however, there are no apparent signs; he was yet certainly in as eminent a degree the prince
of

of philosophers, as Hippocrates was, in respect of physicians. The advances which the philosopher gave to anatomy, though chiefly comparative, are by no means inconsiderable ; and although his books concerning the history and generation of animals have, in many places, absurdities, and even falsities, seemingly too gross to be imputable to so learned an author : yet our great Harvey thought his time well bestowed, both in reading and studying of him, when he was employed on that subject. Among other particulars, you may see good histories of generation, by the egg and incubation (*Hist. lib. 6. cap. 3.*). In the next book, he gives a true description of the disposition of the human foetus, and the gradual completion of the organized parts, so as to be evidently the founder of the anthropogenetical system, which implies a successive organization and apposition of the parts, espoused by his no less admirer than corrector Dr. Harvey himself, and now more largely proved and explained by ourselves, in the present compendium, §. 857.

§. 10. As Hippocrates laid only the first stones of anatomy, so his system is proportionably the most scanty, and the least useful ; whence his visceral anatomy would fall much short of the compass of a good sheet ; but as he appears to have excelled in the knowledge and practice of surgery, at least as a director, so his accuracy and anatomical skill appear more amply and evidently extended, in his accounts of the bones, joints, &c. that have a nearer alliance to assistances from the hand. As Hippocrates

crates found it experimentally more instructive to himself, and salutiferous to his patients, to remark the naked facts, courses, and operations of nature, medicines, and diseases themselves, unmixed with precarious speculations from any philosophy; so he appears no friend to any one theory, more than the evident and sensible qualities of heat and cold, dense and rare, solid or fluid, &c. apparently connected to the objects under his enquiry. If this aversion to theory will not entitle him to any honour in founding the dogmatical or reasoning sect, we apprehend his system has suffered no material loss by it, unless the philosophy of those times had been more perfect: or even if his great successor Galen had altogether pursued the same method, his works would have been doubtless as much more improved in their practical usefulness, as in their brevity.

2. His PRACTICE was generally to leave the whole course of the distemper to nature, under a due regimen, until some very urgent symptom or change called for his assistance; and then he as boldly attacked it by remedies, equally potent; such as excessive blood-letting, ad deliquium, excessive doses of drastic medicines, that both vomit and purge, hot and cold bathing, cupping, unctions, clysters, &c. In acute diseases, he relied principally on plenty of emulsions, hydromels, grewels, and a watery diet, giving cordials when the heat seemed too low, and bleeding, bathing the feet, &c. when it ran too high; patiently waiting for the concoction of the morbid matter, by the powers
6 of

of nature, and as diligently watching the outlets, to which it had a tendency, where he then always promoted the discharge, if it seemed to require assistance, from evacuants. He directs *castor* and *myrrh* for hysteric fits, suppressed menses, and most disorders of women. He gives *vinegar* in quinsies, and ardent fevers, with hiccups, vomitings, phrenzy, peripneumony, and pleurisy: also for viscidities in chronics, dropies, external pains, inflammations, and cutaneous defecations, &c. *Garlick* for cold phlegm, and erysipelas of the lungs. *Alum* to cure hæmorrhages, uterine discharges, and procure conception. *Spices* for phlegmatic distempers of women, and to promote the menses. Recent *ox-gall*, to loosen the bowels, kill worms, purge children, relieve dropies, &c. *Cantharides* in dropies, and to provoke the menses. Diet of *onions* in a jaundice, and to provoke conception. Long *abstinencies* from food, for the cure of dropies, jaundice, diarrhæas, gouty or rheumatic pains, asthma, and disorders of the lungs, or spleen. *Clysters* for pains, inflammations, and over-fulness in the head; dry, hot, and windy cholics, pains of the abdomen, womb, pleurisy, fevers, pains of the loins, &c. *Concussions* towards replacing the bones; and to the discovering of confined pus or matter. *Cupping* for pains in the head and eyes, bruises, peripneumony, pains of the hip and other parts. *Elaterium* to purge bile, expel the fœtus, or purge in cancers, ulcers, jaundice, sore-throat, &c. *Frictions*, with oil, to strengthen weak joints, and relax stiff ones.

Cold-

Cold-bath, for faintings and hysteric fits, restrain the menses, prevent miscarriage, rheumatic pains, &c. but to be cautiously avoided in disorders of the lungs and liver, tabes, &c. *Galbanum*, as a uterine medicine, and an expectorant in a peripneumony. *Juniper-berries*, to provoke urine. He calls eggs *lac pulli*; and adviseth *asses-milk* in excessive fluxes from the bowels, or womb; for flow-fevers, consumptions-purulent, disorders of the lungs, gout, &c. *Lintseed* in wounds and ulcerations; and outwardly in emollient anodyne fomentations. *Sower oranges*, or smelling-apples, in drinks for fevers. *Meconium* for excessive fluxes and pains of the uterus. *Honey* as a resolvent in fevers and phlegmons; as a pectoral in coughs, and a laxative in clysters. *Mint* as a cordial and a stomachic; for jaundice, and vomitings, &c. *Myrrh*, for most disorders of the stomach, and menses; and to cleanse ulcerations in the mouth, gums, and other parts. *Nitre* from Ægypt (redish, and more lixivial than ours), for quinies, pleurifies, gouty and rheumatic pains; also to purge phlegm from the bowels, water in an anasarca; for scirrhusities in the womb, or elsewhere. *Origanum* for cold-phlegm, dropsies, jaundice, &c. *Eggs*, their whites to be given in fevers, not ardent, in the drinks; and their yolks for coughs in children, excessive uterine fluxes, &c. *Poppy-juice* for hysteric pains, and convulsive disorders, hectic fevers, fluxes of the bowels, &c. The water from pitch or tar, and the *pitch or tar* itself, inwardly for ulcers, to expel water from the womb, &c.

Pepper,

Pepper, topically for the tooth-ach, and for cramps. *Cerus* of lead, for disorders of the eyes, skin, and sharp ulcerations. *Penny-royal*, for fevers, and hysterical disorders. *Resin* of turpentine, for inward ulcerations, and excessive fluxes, uterine, &c. *Rose-leaves*, for a diarrhæa, diabetes, and uterine relaxations. *Elder-berries*, to purge, in dropfies and uterine disorders. *Scammony*, root and juice, to purge in hip-gout, jaundice, nephritic complaints, &c. *Squill*, to purge in uterine and pthifical cases.---*Tapping*, for a dropsy, and empyema. *Whey-drinking*, for the cure of ulcerations, consumptions, fevers and gout. *Assa-fœtida*, for hysterics, peripneumony, pleurisy, jaundice, &c. and in a larger dose to purge bile. *Sulphur*, for ulcers, pulmonary and cutaneous disorders. *Frankincense*, for ulcerations, puerile asthma's, stomachic and uterine disorders. *Venæ-section*, with a large orifice to relieve distending pains of the head, eyes, throat, sides, oppressions at the heart, and mouth of the stomach, suppressed urine, &c. but to be omitted when the pains are to be suppurated, &c.

3. This may suffice to give us some notions of the chief articles in the materia medica of Hippocrates, with the uses to which he applied them; and this, we see generally in a conformity with our practice at the present day. His physiological and nosological skill were still much more superior. He had a happy readiness and sharpness of penetration into the state of a patient and his disorder, from all collateral symptoms; by which, and from long observation,

tion, he was almost infallible in his presages of their crises, turns, and future events. In points of surgery, himself and his Latin imitator or transcriber, Celsus, have both of them performed to a wonder. His morbid cases or histories are fully and most accurately stated; and with such an impartiality to truth and interest, that few, if any, can be since compared to him; for he does not scruple to own the least circumstances of his unsuccessful practices. His aphorisms, englished by Dr. Sprengal, with his tracts upon regimen of the non-naturals (elegantly turned into French by *Sieur. A. Dacier*, and in part englished by *Dr. Clifton*), afford not only the best part of his practice, but are filled with a sensible philosophy, concurring with the circulation, and able to endure the test of the present and future ages; as you may see plainly in the nervous, useful, and severe tryals to which *Dr. Gorter* has lately subjected each of his aphorisms, in point of sound practice. *V. Comment. in Aphor. Hippoc. Lug. Bat. 4to. 1740. & seq.*

4. He justly, with ourselves, divides the body into retaining solids (*τὰ ἰσχοντα*), and included fluids (*τὰ ἐνισχομενα*); under which last, he ranks the (*ἐνορμῶντα*) movers of the body and mind, now called nervous spirits. He distinguishes the red blood from the yellow and watery serum; and observes, that in the first there is contained a fibrous substance, which being drawn out from it, the rest will not congeal. He appears plainly to have known the perspiration, exhalation and inhalation, that obtains
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through all parts of the body ; on which Dr. Kaw (a relation of our great Boerhaave's) has given us a professed, elegant, and useful treatise, entitled *Perspiratio Hippocratica*. And it is no less plain, that he knew the blood and juices had a circum rotation or return through the several parts of the body ; although he knew not how or which way it was carried on, by the nature and organizations of them. See the remarkable passage in lib. de insomniis, n^o. 13. But since either abridgments, or whole copies of so considerable an author, are in the hands of almost every one of the profession ; instead of further details, we refer them to the original ; of which the late Venice edition, 1737, translated by Cornaro, is the most useful, to a novice or a busy practitioner, on account of two indexes, each as big as the original work ; which is here turned (1.) into a system in alphabetic order, by Marinelli ; (2.) a concordance, or index, by P. M. Pinus.

5. Only we shall by the way remark one thing surprising to some, why in the midst of so accurate attention to all the other signs, both diagnostic and prognostic, that are at this day regarded by the greatest physicians all over Europe, Hippocrates should have taken so little notice of the pulse, as barely to mention it in a very few places. To this we answer, that his close repeated and ingenious observation of respiration *, (now commonly as much neglected, as the pulse was by him) in regard to its magnitude, frequency, strength, facility, &c. with their degrees and opposites, showed
both

both to his eye and ear, all and more of the same instructions than he could learn from the pulse; which being only a consequence of the former, and of the same import, easily fluctuating or deceptive in various parts, and under various influences, he often neglected it as less to be trusted, and not so apt to surprise or sound his fame in predictions: although he has left us enough to show, that he consulted the pulse of the arteries, as a sign in all such cases as he judged to require it.

R E M A R K.

* Here I must confess, that although I cannot acquiesce with the learned Dr. Nicholls, in his late elegant prelection; *de anima medica*, Lond. 4to. 1750. in allowing the mind any other operation upon the body than what is re-actional, directive and conformable to the impressions which the body itself, first organized, conveys to her, so as to determine her re-action, which in conscious changes we call the will; yet I must own, that an afterthought, upon what in my younger days seemed an absurdity, has made me admire the wisdom of the ancients, in giving the same name to the diaphragm (*Φρενες*), which is used to denote the mind, of whose various states or conditions it is no less an index than to those of the body. For this part is actuated by the common spring of nature, the atmosphere, at the birth, before there are any powers of will, to which it afterwards pays certain degrees of obedience. This part appears to be the regulator of the heart, and by that also of the encephalon, and by both of the bodily affections or impressions upon the conscious mind; and this even on the first day of birth, long before she has any conscious determinations of will; and on the last day of life, long after both will and consciousness have ceased: so on the
other

other hand, the re-acting mind returns her operations primarily and principally by the nerves of these parts, to the rest of the body, in producing all the morbid affections, ascribed either to elevating, or depressing and sorrowful, passions of all kinds. Hence the natural languages, or vocal clamours of all animals immediately result, expressive of their then conscious state, to any ear they can reach: for as the mere tones of voice, conformed to the intentions of the will in man, are able to express different senses by one and the same word, so there is hardly an observing person, but what can readily determine, if they hear the voice either of man or beast, articulated or not; whether it arises from a passion that is sorrowful, joyous, or indifferent: for whenever the mind, has so far deserted the society of the body from any infirmity thereof, as to be incapable of passion or will, she can return no effects of them upon the body, and consequently can return none of their effects again by the voice or other actions of the body. Hence there is an elegant paper in one of the philosophical transactions, intimating the way of judging people's general and present dispositions, both of body and mind, by the natural and common keys or tones of the voice. But to trace this matter through man, and other animals in general, is a subject indeed curious, useful, and elegant, but too long for this place.

§. XI. After Hippocrates had made physic a liberal and distinct art, to be further perfected by observation and practice, his works continued, making some improvement in the hands of his successors, the Asclepiads, or descendants of Æsculapius, until about the dawn of christianity, both the original and the additions were accurately digested and improved into a kind of

new system, by a learned Greek, named ARETÆUS Cappadox, in four books, entitled, *Concerning the causes and signs of acute and chronic diseases*; of which the Oxford edition, by Dr. Wigan and Mr. Mattaire (fol. 1723), is as near good as any since made. This physician, who seems by his writings to have practised at or near Rome, has given us more exact and beautiful histories of diseases, than are to be found in the rest of the ancients; and his methods of cure are proportionably more elegant; but unfortunately the whole is in many places imperfect, by the loss of whole chapters. He seems to appear with all the superiority over Hippocrates that time and collections could afford him; and is not equalled, either in method or elegance, by any writer after him. He is the first that applied cantharides for the use of blisters; he used bleeding ad deliquium in a quinsy, and applies much to the masculine practice of the Romans, by diet, exercises, bathings, sweatings, fomentings, &c. But his elegant descriptions are most valuable, because just, compact, in one continued narrative, and placed in a good order. The like we may say of the Latin Hippocrates, CELSUS, who wrote soon after him, in a choice Roman diction, equal to the majestic and elegant Ionic dialect of Aretæus's Greek. Therefore if we add these to the learned expositor of Hippocrates, GALEN, who flourished soon after Celsus, and in the same great city, we shall hardly meet with any writers worth notice afterwards, unless it be TRALLIAN, down to the end of the 15th century;

tury ; or even in the following 16th age, little more was done than variously cutting and carving, contracting or dilating the doctrines of those fathers, after divers forms and manners. Of Celsus, you may consult the Padua edition, 8vo. 1746. in which are contained Morgagni's elegant observations and remarks *, in five or six epistles.

R E M A R K.

* Those who are curious to trace the steps by which medicine has descended from the hands of *Galen*, into our own, at the present day, may compare him, or his abridgment, by *Lacuna*, with (1.) *Jacobus Sylvius*, Parisian professor; then (2.) *Riolani* opera, fol. Par. 1610. & seq. (3.) *Sennerti* opera. (4.) *Riverii* opera. (5.) *Etmulleri* opera, (6.) *Hoffmanni* opera. (7.) and lastly, the theoretical and practical courses of our late illustrious European *Æsculapius*, *Boerhaave*; the former given us by Dr. Haller, re-printed with the text, in seven volumes 4to. Ven. 1744, and the latter half published, and now on the anvil, by Dr. Swieten, at the imperial court; to which add the works of his diligent and well commended scholar, Dr. Gorter.

§. XII. The great luminary of medicine, *GALEN*, whose works have eclipsed all those of his cotemporaries and successors, down to the times of Harvey, flourished at Rome, during the latter part of the second age of christianity, was by birth an Asiatic, or Greek, born at the city of Pergamus, son to the expert mathematician and architect, Nicone, an. Christi. 131. After compleating his studies at Alexandria, he began his practice, at the age of 34; and soon

after travelled to Rome, where he wrote his so much admired and voluminous works, filled with learning of all kinds. He afterwards returned into his own country, but was soon recalled to be chief physician to the emperors Antoninus Pius, and Verus; after whose decease, he retired again into Asia, and there died in an advanced age. Galen has supplied to us the common fountains from whence the physiology of the human body has been taught, for near fifteen ages after him, down even to the times of Harvey; and although he is generally tedious in his expressions, often unsettled in his opinions, and frequently gives us confused intermixtures, by transcribing both the human and comparative anatomy, intermixed together; yet he is still a very deserving and professed anatomist, the last of the Greeks, the most eminent of all the ancients, and far from deserving many of those aggravating reflections thrown upon him by Vesalius; more especially that of having never traced the human body itself, by his own labours; the contrary of which is evident, throughout his book *de usu partium*; and from the passage (*lib. 3. cap. 2. de comp. med.*); where he tells us, the bodies of barbarians, killed in the battle of Mark Antony (*an. 174.*), were given for dissection to the Roman physicians. We are probably obliged to Galen for the works of Hippocrates himself, no less than for many remarkable passages of the ancients, that are not elsewhere to be found. In his said treatise on the use of the parts of man's body, he evidently describes the foramen ovale, and

canalis arteriosus in the fœtus, the true course of the blood through the lungs, with the use of the valves, &c: he has left us also a number of autographical descriptions, and experiments on living animals, no less useful in physiology than practice; in which last he appears throughout truly the great man in all his works, which with those of Hippocrates and Celsus, will ever continue to be a pleasurable and instructive entertainment to all who have judgment, time, and ability to read them. Galen's books concerning the powers of simple medicines, have been transcribed, with but little alteration, into *Oribasius*, *Ætius*, and *Paulus Æginita*; and they also form the chief part of what the Arabians have afterwards given us upon the subject of simple medicines. His distinctions of the various kinds, causes, and symptoms of all diseases; particularly fevers, shew the penetrating depths of his genius, above any of his predecessors; and his perfect acquaintance with the philosophy of Aristotle, that then flourished at Rome. His six books concerning the knowledge of the seats or parts affected, in diseases, are both valuable and admirable, beyond other parts of his works, of which they were probably some of his last; and are preferable not only for their good method, and more compact diction, but for the justness and validity of the diagnostic signs, proposed for discovering the more obscure diseases, and for the many observations he has given us from practical anatomy. Nor are his merits less in prognostics, than semiotics; only we must disregard the useless excesses,

cesses, to which he has, in complaisance to Aristotle, extended the peccant qualities of humours ; and the endless variety of pulses, that are not perceptible to the nicest and most experienced touch. His three books upon the natures or powers of aliments, have continued the ground-work of all that has been said on diet by his successors ; and his disquisitions into all the kinds of foods, with their relations to an easy or difficult digestion in the stomach, show the greatness of his judgment, and the extent of his experience ; which are both of them still more conspicuous in his six books upon the preservation of present health ; in which, besides the aliments, he considers their relations to the several ages of man, from the birth and upwards, advising, in conformity to the age, suitable exercises, frictions, bathings, evacuations, wines, and foods, contrary to the morbid dispositions. Of these books, formerly Sanctorius, and latterly Sir John Floyer, have made a very good use both in their practice and writings. Sir John tells us, that Sanctorius made his great discoveries upon the important subject of perspiration, from reflecting on the following passage of Galen's sixth book *de fanitate tuenda*. *Ægrotare autem solent vel humorum vitio, vel redundantia. Ubi igitur quod exhalat à corpore minus est iis quæ accepit ; redundantie oriri morbi solent. Quare prospiciendum est, ut eorum quæ eduntur & bibuntur respectu eorum quæ expelluntur, servetur conveniens mediocritas. Servabitur sanè is modus si ponderetur in nobis utrisque quantitas. Et*

porrò

porrò de nutrimenti, vel quantitate, vel qualitate, vel etiam utraque detrahimus. This by the way may serve as one instance, how useful a cool reading of the ancients may be in the hands of able professors, even merely to excite a spirit of invention, and afford discoveries, which perhaps the ancients themselves were very little acquainted with. As for surgery, it must be owned Galen falls very short of his predecessors, Celsus and Hippocrates: and indeed he seems to have been not very fond of it, when he tells us, that “as an emperor must sometimes go
“and fight himself for a soldier; so a physician,
“in cases of necessity, must make use of his
“hands.” However, he has largely enough treated upon inflammations, tumors, wounds, ulcers, blood-letting, cupping, scarification, &c.

§. XIII. 'Tis universally allowed by all good professors, that Hippocrates, Aristotle, and Galen, form together a triumvatic system of the ancient anatomy; which, if digested would even at this day make a very formidable appearance, and go near to equal the most considerable additions that have been since made by others, even down to the arising of the three greatest luminaries of modern dissection; viz. Vesalius of Paris, Eustachio of Rome, and Harvey of London. But those who through choice or incapacity desire to be disencumbered with the volumes of the triumvirate, may rest satisfied with a marginal abridgment of them, that attends the anatomical system of Caspar Bauhin*,

* Caspari Bauhini Theatrum anatomicum Francoforti 1621. & 1640. 4to.

which, joined with the said luminaries, and the tracts of accurate Riolan *, will very well bring down the state of anatomy to the midst of the last century; and then the last edition of Bartholin †, joined with that of Verheyen ‡, will reduce it to the dawn of our present age.

2. Those who desire to be acquainted with some of the principal matters contained in most of the Greek and Latin writers, who followed after Galen, down to the restitution of learning by the art of printing, in the midst of the 15th age, may consult Dr. Freind's history of physic, for that period. For in reality, the additions made to the art of healing in that interval, are so inconsiderable, that if we except half a dozen writers, the rest may be over-looked without any sensible loss. Of these the first considerable author, contemporary with, or near to the time of Galen, is *Cælius Aurelianus*, Siccensis ex Africa, in his eight books, de morbis acutis & chronicis, 4to. Amstelod. 1722. who is not only just in his signs and descriptions of

* Riolani Archiatri Enchiridion Anatomicum cum dissertationibus adjectis. 8vo. Paris. 1658. Animadversiones Anatomicæ, 4to. Lond. 1649.

† Thom. Bartholini Anatomia quinta vice ad circulationem reformatà Lug. Bat. 1686.

‡ Philippi Verheyen Anatome, Lovaniens. 4to. 1693. without which system, you will meet with the gold picked from the dross, in Dr. James Keill's anatomy of the human body abridged, 12mo. Lond. 1698. or rather Dr. Drake's Anthropographia; in which you have also many of the figures and observations of the ingenious Mr. Cowper,

diseases, but has preserved to us many significant fragments, from the ancients of his day, that are otherwise lost to us. Among other particulars, he takes notice of the hæmorrhoides or piles, in the coats of the bladder, that bleed periodically, or at uncertain intervals; and is a case that occurs sometimes in our days, no less than his. *Oribasius*, of Pergamos, who flourished physician to the emperor Julian, in the midst of the fourth age; was a pagan, like his master, by whose order he gathered seventy books, under the name of collects, from the most eminent ancients; of which only the first 15, with the 24th and 25th, are preserved to us. Physic appears thence to be already degenerating, at least with *Oribasius*, towards recipe and superstition. However, he has many pertinent fragments of the lost ancients; and the diseases, of which he is the first describer, may be seen in Dr. Freind. *Ætius* Amidenus, who next flourished in the close of the fifth age, one of the first among the christian physicians, is more ample than Galen, in respect to surgery. He highly commends and describes several kinds of cauteries; and uses scarifications of the ancles in dropsies. He treats of blood-letting, sinapisms, clysters, pessaries, the bites of animals, herniæ, abscesses, scirrhi, cancers, and encysted tumors. He has freely compiled from his predecessors, and transcribed almost the whole of *Oribasius*, upon simple medicines, into his second book. But in points of surgery, he appears much fuller than *Oribasius*; although he subjoins an infinite number of recipes to each distemper, with long details

details of their virtues; which are plain indications of the idle, ignorant, and superstitious condition into which the art of healing was then about to dwindle; together with the language and the other learning of the empire. Alexander *Trallian* of Lydia, in the lesser Asia, flourished in the midst of the sixth age, under Justinian; said to have been a good christian and physician to St. Leo the great: though one of the last in order, is the first upon the line of merit, next to Galen. For he has given us a concise, just, and systematical description of all diseases and their medicines, from head to foot; but without including surgery, or the diseases of women. In his practice or curative part, he has greatly excelled both Hippocrates and Galen; he subdues quinies by repeated blood-letting, an hæmoptoe, by bleeding in the foot, coolers for erysipelatous fevers, worm-wood for bastard-tertians, &c. He is one of the first that commends bleeding in the jugular; and remarks the astringent virtues of rhubarb, &c. A compendium of him may be seen in English, by Dr. Milward; Lond. 8vo. 1734. Trallian quotes his predecessor *Ætius*, as he himself is quoted by his successor, Paulus *Ægineta*, in the close of the seventh century. *Ægineta* is the last upon the Greek list, and has supplied the parts of surgery, and midwifry or diseases of women, which Trallian had omitted, and from whom in most places he has largely transcribed. His descriptions of diseases are compact, and taken chiefly from Galen and Oribasius. You have his works in Latin at Paris, 1532. fol. and from the

the press of Aldus at Venice, with notes, 8vo. 1553, and 1554.

3. After the Roman language and arts had been ruined in Italy, by the Lumbards, and those of the Greeks much declined in the east, about the close of the sixth age; soon after there arose a crafty impostor, Mahomet, who in the beginning of the seventh age, endeavoured to suppress learning and arts in others, the better to establish his own empire and superstitions; although at the same time he is said to have known so much of medicine himself, as to write a book of aphorisms. He and his successors removed physic, with the schools from Alexandria, among the false priests and prophets of their own tribe, to cities called Harran and Bagdat; and after carrying their empire with the rapidity of a torrent, over most parts of Persia, Arabia, Ægypt, Asia, Palestine, and Africa, they translated what was thought valuable of the sciences, into their native Saracen, or mixed Arabic language, and soon suffered both the first fountains, and the learned languages, to perish in favour of their own. In the beginning of the eighth century, they became masters likewise over a great part of Spain, where their Musselmen also obliged the remains of the sciences to speak their own dialect. Physic rather losing than gaining in the hands of the Arabs, however maintained its bulk, and gained some things, while it lost others; particularly their own practice, often lead them to milder and better medicines, than what had been used by the Greeks; only by too much

much neglecting the Hippocratic knowledge of diſtempers themſelves, they ran almoſt entire into the Galenic forms and compositions. Among theſe flouriſhed *Serapion*, in the cloſe of the eighth century; John of Damascen in the miſt of the ninth; *Rhazes*, præfect to the hoſpital of Babylon, in the dawn of the tenth age. His works ſhow him to have been one of the greateſt Arabian phyſicians, as they make a conſiderable folio; Baſil. 1544. and include all branches of phyſic and ſurgery, with many things new, and uſeful in each: here we have mercury ſublimated, and many other chemicals, a proper deſcription and cure of the ſmall-pox and meaſles, &c. At the cloſe of the tenth age, *Haly-Abbas* gave a full compendium of phyſic. In the dawn of the 11th age, *Avicenna*, of Buchara, or Uſbec in Tartary, who has compiled a large ſyſtem from the Greeks. *Avenzoar* was a Spaniſh Arab, native of Seville, and præfect of the hoſpital there, in the 12th age: contrary to the cuſtom of the time and place, he practiſed both ſurgery and phyſic, together with great judgment and ſucceſs, and has left many good obſervations, rare caſes, uſeful and new medicines, &c. fol. 1496. & ſeq. Venetiis. *Averroes* was alſo a native of Corduba in Spain, a ſubtle Ariſtotellian; but afterwards taught, and died in the city of Morocco, an. 1166. leaving nothing remarkably uſeful in his works. After him followed *Meſue*, who excelled in the Galenic pharmacy.

4. The Arabian phyſic, was, in the cloſe of the 11th age, put into a Latin dreſs, by *Conſtantine*

stanus the African, of Carthage, who is said to have lived 39 years in the city of Babylon. He in the year 1087, carried it to *Salernum*, by Naples, the first and oldest school of Italy; where he left his seven books de Morborum cognitione & curatione; the manuscript of which is said to be still kept at Vienna. He afterwards died at Monte-Cassina; and his works were printed, Basil. 1536. & 1539. fol. This Schola Salernitana, is the oldest for physic in Europe, and grew up from an unknown origin, 'till it got a considerable name in the midst of the 11th age, by sending rules of diet in verse, for our prince Robert, an. 1060, son to William the conqueror: and in the close of the 12th age, it got the name of the Hippocratic college, consigned from abbot Joachim.

§. 14. As the reviving arts in general began to lift up their heads in that quarter of Europe, which we call Italy; so physic and anatomy made their more early and considerable appearances in that country, especially the school of *Salernum*, by Naples, before they travelled on to France, Germany, and Britain. The first dawnings of anatomy were probably in Sicily, under the emperor Fred. II. who at the close of the 13th age, erected Sardinia into a kingdom, for his son Ellzo, who died under confinement at Bologna; for he enacted a law, that none should be allowed to practise in surgery, who were not dissectors in Anatomy: but his first physician, Martian, got leave to reduce it to a public administration, every five years, at which all physicians and surgeons were to give

their attendance. Soon after this, *Mundinus* became so celebrated a professor at the university of Bononia, in the entrance of the 14th century (where anatomy had been taught for an age and a half before him), that a public law was obtained for obliging all doctors in Italy to lecture out of no other book than that published under the name of Mundinus, at Bononia, in the year 1315; in which, however, as well as his commentator J. B. Carpus, there is so much rusticity, both in the diction and the described matter, that the book has little to recommend it, more than its antiquity.

2. But in the midst of the said 14th age, flourished *Guido de Chauliac*, who being in holy orders, was no less chamberlain and chaplain, than principal physician to several pontiffs of the holy see; but is much more considerable for his writings in surgery, than for the collected abridgment he has left us upon anatomy. He was an eye-witness to the general plague that invaded, not only Italy, but all Europe, in the year 1348; and of which so many died, here at London, that in the said year 50,000 were buried in the church-yard of the charter-house only: which plague he afterwards describes in his works, wrote in 1363, at Avignon (which had from the year of the said plague, been made a retirement for the pontificat), under his master Urban the V. who is himself said to have been the son of an English physician. In the days of Guido, surgery had been so far lost, that the best professors in Europe, four of whom were in the

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sacer-

sacerdotal order, scarce knew how to treat a simple wound. Rogerius of Venice, and Roland of Parma, knew no better than to poultice them with a few herbs, mixed with wine and honey; Bruno of Padua, and Theodoric, bishop of Cervia, relied upon sweet wines, mixed with restringents; Salicetus, professor of Verona, and Lanfranc of Milan (who wrote his works at Paris, in the end of the 13th age), preferred the use of sweet-ointments and plasters; nor is any thing better proposed by John of Gaddeſden, under king Edward II. and III. in his *Rosa Anglica*; but the Germans treated their wounds by charms, and mixtures of oil and cabbage.

3. Guido being a man of letters, one of much reading, and assisted by the pontifical libraries, took upon him to relieve this dearth of chirurgical knowledge (that had prevailed, from the time when medicine passed, from Paulus Ægineta, into the hands of the Arabians, at the close of the sixth age, among whom it lay buried from Europe six ages more), by recollecting the operative parts, as far as they had been treated in Galen, Ægineta and the Arabians; not neglecting what he thought useful in his cotemporaries, Theodorus, Salicetus and Lanfranc. The former, Theodorus, though averse to all operation, had recommended turpentine as the best application, for wounds of the nerves; with a double ligature, upon the artery, to be divided, for suppressing an hæmorrhage. Salicetus had approved futures for wounds of the abdomen. Lanfranc had treated
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on the operations for the stone, herniæ, and dropsies; although tapping the abdomen for the last, he says, was always fatal in the end. He first condemned the use of tents, and advised futures of transversely wounded tendons, in which Theodoric had been timorous.

4. Guido, however laudable in his writings, and experienced in his practice, is not to be commended for using futures in lithotomy, and castration for the cure of herniæ. He both used and describes the trepan for wounds of the brain, while others trusted only to topicals; he used futures of the tendons, with good success, and describes a great number of instruments for various purposes; and among them are forceps for the tying up of arteries, &c. From all which he has deservedly gained the repute of being an Hippocrates, or restorer of surgery to Europe; also the first that separated or planted off surgery from physic, reduced it to a distinct system, and confirmed it by his own repeated observations and experiences; whereas the offset of pharmacy, is much later.

5. Some time after Guido, men of letters began to perceive the merits of Hippocrates, Celsus, and Galen, above the Arabians; who had been as yet the store-keepers and retailers of learning, from the seizure they made of it, together with Spain, in the dawn of the eighth century, even down to the 12th and 13th age, when by retailing the Greek learning in their own dress at Toledo and Corduba, they acquired great fame, by a conflux of students from the other, at that time ignorant countries of Europe;

Europe; where the returning students appeared so much more learned than their neighbours, as gave occasion for a rumour, that Dæmons professed and taught the arts, about those cities of Spain, where even block-heads might become learned for their stipend.

6. From these ancient Moorish universities of Spain, astrology, physic, and chemistry were learned and carried into France, by Arnoldus de Villanova; and by Peter d'Albano, to Padua, at the close of the 13th age. But they no less than our Oxford R. Bacon, suffered for their extraordinary knowledge, by the popular, but unjust imputations of dealing in magic or forcery.---During the fourteenth century, arts and sciences made very inconsiderable advances in Europe, until the refugee Greeks, expelled from their metropolis, by the Turk, and the discovery of the art of printing in the midst of the 15th age, revived the drooping spirits of Minerva, and amply diffused true and useful knowledge through all the veins of Christendom. The Greeks having opened the learned treasures of their country in Italy, they were soon sent abroad at an easy rate by printing, both in their primitive, and in the Roman dress. Celsus came out at Florence in 1478, and at Milan in 1481. Aristotle and Theophrastus at Venice, under Aldus, in 1499; and soon after, from the same press, came Dioscorides, Galen, Hippocrates, Paulus, &c.

In the dawn of the 16th age, some of the sharper wits, who had digested upon the fathers of learning, began to perceive, that al-

though Aristotle and Galen had been pre-emptorily erected as the touch-stone for all truths; in behalf of which, a philosopher could have no where any quarter further than he had their arguments to support him; yet they found the springs of nature, no less than those of human understanding, continued to be still the same; and that even these oracles were no further meritorious than as they had faithfully trodden in the steps of nature herself, at whose tribunal Vesalius was one of the first who with a laudable courage, called over the justness of their titles; upon the summing up of which, as Aristotle and Galen were found preferable to the Arabians, so Hippocrates and his imitator Celsus, appeared fuller of truth than them all. These measures soon bred a party, chiefly in France, who discarding the absurdities and idle theories of Galen and Aristotle, espoused nothing but what they canvassed by the rule of sensible experience, and plain reason, under the name of the Hippocratic sect; because Hippocrates, regardless of all nominal authorities, has pursued the same course. In this list, after Vesalius, we rank Jacobus Sylvius, our British Cajus, and Sir Thomas Linacer, Baillonius, Duretus, and their respective disciples Jacotius, Heurnius, Mercurialis, Fœsius, &c. whose writings are therefore at this day both legible and instructive.

§. XV. Vesalius was born in the beginning of the 16th age, with a spirit for the restitution of anatomy, to which he applied so arduously, that he gave public lectures in Lovain and Pa-

ris, by the age of 18; and became successively its professor to the universities of Padua and Bononia. He was at last fixed in that of Pisa, by a salary of 200 pounds sterling per annum, at his 23d year of age; a sum at that time egregious. His cavilling disposition however made him unhappy in himself, and despicable to most of the learned; and after publishing his system, he seems to have entirely thrown up anatomy from his 29th year; being then called to the service of the imperial court and army, in which he made an excellent surgeon. He is said to have ended his life untimely, in a voyage to Jerusalem, 1564, either devotional or penal. In his great work (*de corporis humani fabrica*, fol. Basil. apud Oporin. 1543, & 1555.) lib. 1. he gives us an excellent osteology, freed from the mistakes and absurdities of Galen, whose errors he severely refutes, illustrated with neat and strong figures, drawn and cut with great art. In his second book he gives us 18 tables of the muscles, of which the first, second, third, and fourth, represent the strong life, and have therefore been usually followed, as models for painters, &c. His descriptions are also much more minute than had as yet been given; but excelling as they both are, they have notwithstanding their faults, in great numbers. In his sixth book he has restored the true figures and situations of the mediastinum, pericardium, and heart, conformable to their natural appearances in the human body; which till then had been corrupted by his predecessors, in copying from

brutes. His figures of the brain are the first that can bear inspection. He is the first that figured and described the valvula pylori, with the spinal lymphatic glandules behind the œsophagus, and the epiploidal or fat appendices of the colon. It must yet be owned, that the course of the arteries and veins, as figured to us by Vesalius, and copied by his successors, are as defective as any part in his book; and fall infinitely short of the Eustachian accuracy. The same may be said of him in respect to the genitals of the female, which he copies chiefly from brutes, as well as the kidneys. His dissections of the eye, are from cattle; and his perseverance in asserting a seventh muscle that is in them, to be also in the human eye, after being admonished by Fallopius, is both obstinate and egregious; as is also his denial of the optic or blind pore in the nerves, &c.

§. XVI. Barthol. Eustachio flourished as public professor at Rome, cotemporary with Vesalius, and has well merited the title of the prince of anatomists, both ancient and modern. He learnedly rescues Galen from many wrong and malignant accusations of Vesalius, and shows his descriptions were of the human, and not of the monkey skeleton; but in some places is himself culpable of vindicating a falsity. He first describes the tube, called after his name, with the bone stapes; and in treating of the teeth, he has almost quite exhausted the subject, and given us a fair specimen, how compleat a system we might have expected from him, had he been healthy and able to have gone through

through it. In his posthumous tables, which will ever remain the master-piece, betwixt ancient and modern anatomy, he gives figures of skeletons, much more correct than those of Vesalius, only rather too smooth, or from too young subjects; to which he has subjoined separate views of the most difficult bones, from a dismounted scull; the multiform or sphenoidal bone is elegant, and in the upper jaw you see the antrum ascribed to Highmore, and largely noticed by Mr. Cowper, in the system of Drake. Eustachio gives us many systematical tables of the muscles, truly drawn from nature, and disposed according to their strata or situations, from the surface to the bones of the body; these he proposes as a continued critic upon the more defective tables of Vesalius; and has in many parts rivalled the supposed discoveries of Mr. Cowper, and other professed muscular anatomists of the present age, in the face, larynx, pharynx, ear, genitals, eyes, &c. These tables appear to have been formed on the same plan, and with the same industry used in the late muscular tables of Albinus; which are finished in the highest perfection. He not only restores the heart to its natural and just position, but also gives an elegant view of its proper arteries and veins, with those of the lungs, and his valve at the coronary vein. tab. 15, and 16. In his figures of the encephalon and nerves, those of tab. 17, 18, are incomparable, both for labour, correctness, and fulness: and those following to the 24th table, in which the courses of the nerves amongst the bones and

muscles are graphically viewed, continue the wonder of all wiſe anatomists, and as yet without a fellow; as are those of the blood vessels in the same manner, while those of Vesalius, Willis, Vieussens, Cowper, and others, drawn like the twigs of a tree apart from the body, are almost a continued puzzle, either useless, or but little instructive. Since Eustachio excelled in the neurography, it has continued, and now remains the least finished of any branch of anatomy. He has reduced the œsophagus to its true figure and situation, with respect to the larynx, trachea, spine, and stomach; in which last he shows the difference of its figure, betwixt being full and empty, the ligaments that join its cardia and pylorus, the true course and figure of the duodenum, colon, liver, spleen, and pancreas; with the mesentery, in which you have plain traces of the lymphatic or lacteal vessels, and their glands, which lead to the receptacle of the chyle and thoracic duct, by him largely described in his book of the *vena azygos*, or *sine pari*. His figures of the liver excel most of the present day; and his varieties of the urinary passages are as elegant, as their descriptions are exquisite; as are also the parts of generation, with their blood-vessels, both male and female: for in the first you see the earliest figures of the seminiferous tubuli, vesicles, caput and oculi galinaginis, at the neck of the urethra, corpus cavernosum, &c. His tab. 14. and 15. on the female genitals, show astonishing industry: for here you have the clitoris and its muscles, the sphincter, vagina, hymen,

hymen, and vasa uteri in their perfection ; with the communicant vessels of the round ligaments, uterine tubes, ovaries, &c. He shows the uriniferous ducts and their papillæ, open into the pelvis ; which last he gives in its true size and situation, to correct what Vesalius had given us from brutes : the oblique entrance of the ureters into the bladder, without valves ; the situation of the right kidney, lower than the left, to correct the opposite and current error ; and proves by ligature on the ureters, no urine can enter the bladder but through them. His exquisite figures of vessels throughout the body, are such as prove him to be acquainted with several sorts of injections ; as he in some measure indeed owns, by declaring water may be urged from the renal blood-vessels, into the pelvis and ureter. In tab. 39 and 40, you have an elegant dissection of the human eye, with all its parts ; to correct the misleading cuts given by Vesalius, from cattle. His descriptions of the organs of hearing, are equally well known, as they are perfect. But his elegant plates lay lost to us 'till about 40 years past ; and have had no significant explanation, 'till one was lately given by his laudable imitator, Albinus.

§. XVII. But to come nearer home, in the midst of the unlearned 13th century, flourished in the university of Oxford, Roger Bacon, a franciscan, and fellow of Merton college ; who by great ingenuity and experimental labours, penetrated not only into physic, but also the principal instruments and operations of chemistry, optics, and mechanics, to a degree that

so far surprized the more philosophic part of the world, that they universally gave him the title of Dr. Mirabilis; while the more ignorant and superstitious part censured him for a diabolical conjurer, and by malicious accusations, procured him great troubles from his superiours, who were too easily misled in his prejudice. After he had been cited for necromancy to the holy see, by the superiour of his order, although he cleared himself by a professed treatise (*de nullitate magicæ*), his companions of the college always continued so jealous of him, as to intercept every body from his conversation, and would allow his books no place in their libraries. These and other difficulties, brought on him by the disclosure of some surprizing experiments, unknown to the day, made him doubtless more reserved in what he afterwards communicated by his writings; concerning chemical experiments, burning-glasses, gunpowder, mathematical instruments, and optical lenses, applied in the way of microscope, telescope, or magic-lanthorn, &c. Wherein he shows himself to have anticipated his country in philosophic learning by several ages, in those of his manuscripts, which make a choice part in the Bodleian library of Oxford. See Dr. Plot. Hist. Ox. c. 9. Freind's Hist. of physic. vol. 2. Father Bacon laments the unlearned state of the clergy, universally seen in his day; and observes, there were but three or four whom he knew meritorious of the title, wise, or learned in Europe, among whom he reckons

Villanova, whose works were public at Lyons, fol. 1520; and Dom. de Garbo, whom he terms the doctor of experiments; and has left us a treatise de Cæna & Prandio. Rome, 1545. fol.

§. XVIII. From the time of the good friar, mechanical and experimental knowledge, which lay the only true basis of medicine, made very inconsiderable advances; 'till towards the close of the sixteenth age, an illustrious lord chancellor of the same name, arose as the great luminary, no less of philosophy, than of law to England. This great man first boldly declared among us, that though he ought always to speak honourably of Aristotle, yet he must in the main condemn his philosophy, as a bundle of insignificant and disputable notions, productive of no manner of benefits to human life: which he afterwards made appear by his own labours, in showing the difference betwixt speculative and experimental knowledge in philosophy. Lord Bacon was born, son to chancellor Nicolas Bacon, at York-house, in the Strand, 1560, and was from his infancy remarkable for quickness of wit, and depth of penetration. Although he had been 19 years chancellor, he died at last subsisting on charity, at the earl of Arundel's, High-gate, 1626; and was buried at St. Michael's, near St. Alban's, from which town he had his title of baron. The additions made to the sciences, as well as to physic and philosophy, by this great man, are too numerous and well known for us
to

to insist upon here, since his learned and extensive works are now become a material part in every good library. But his *Atlantis*, describing a collegiate body of wise men, labouring each in their way to promote natural knowledge, is the more remarkable, as it excited the learned, and gave birth not only to our royal society, but to all the like academies of Europe; in which learning has by their means been since raised to the highest points of perfection. While lord Bacon was improving experimental knowledge in England, the like works were carried on by Gallileo in Italy, whose scholar Torricelli invented the barometer; and by the disquisitions of Mersennus, in France; but as for M. des Cartes, in the Low-Countries, his nobility and mathematics only served to make him more infamous as a philosopher; since deserting the rule of plain reason and just experiment, by which he proposed to erect his system, he has only buried himself and his followers in a cloud of idle absurdities, that too long blinded most of his French neighbours, to the light of a better philosophy. Gallileo was native of Florence, professor at Pisa, and astronomer to the grand-duke de Medicis; after whose name, he called the subsidiary little moons that he discovered, revolving about Jupiter, *Satellites Medicei*. After the ice had been once broken up by lord Bacon, many able heads and hands cheerfully succeeded him in extending and clearing the channels of science; among whom the honourable Mr. Robert Boyle,

Boyle, and sir Isaac Newton appear the earliest and most conspicuous upon the list: insomuch, that at this day, a philosopher is said to be no where able to make a better repast, than from a dish of old English BACON, well BOYLED, and carved out by NEWTON. The advantages that have ensued from the mechanical philosophy of this last gentleman, in all arts, sciences, and occupations of life through Europe, before and after the close of the last age, would alone fill a very large volume; and since Dr. Keill and others have in a series of fifty years past brought down his system by experimental courses, to be the plain object of our senses, no less than of our intellectual reasonings, the study of his philosophy is become equally a pleasing amusement, as an improving instruction, even to the weakest ages and sexes.

§. XIX. But our own profession has of late years received no less improvements, than philosophy herself. For while the last was advantageously laid out upon the anvil, by lord Bacon, a man equally great in the line of *Æsculapius*, struck a new and unextinguishable light to physic in all her branches; by enabling us to understand the manner, operations, and effects of the circulation of the blood; the main spring of all the various motions in the living body, and the only key to all the changes that can happen in it, either under the influences of health, aliments, medicines, or diseases. This important discovery, after it had been some years made, privately taught, and by degrees

degrees cleared up, by the great Dr. William Harvey *, was afterwards published to the world, by a printed treatise in the year 1628. Our British Hippocrates, who pulled off the blind-fold from physic, was born at Folkeston in Kent 1576, was afterwards scholar in Dr. Cajus's

* Now as the Harveian doctrine of the circulation (§. XIX.), is the grand rule by which the knowledge and practice of physicians in general must be raised, squared, and modelled, through all future ages and nations; and as it is alone the true light that can guide us safely and sensibly through the whole physiological and nosological clue of medicine: we may presume, that no lover of truth and mankind, will be displeased to see here a transcript of so many of the great author's own words, as will suffice to give us a plain view of his discovered circulation of the blood, through the heart and extreme parts of the body; which with some other collateral hints, of great importance, have since furnished a large part to this compendium, as we shall point out by occasional references to the sections; which will give a further explanation of each article. — After offering his enquiries for the public good, to the candid reception of his royal master, Charles I. whom he salutes as the true heart of his people; from whence the vital streams of truth, honour, justice, clemency, liberty, and property must flow through all considerable members, to the mutual happiness of himself, and downward even to the least individuals in the British constitution; he then begins by telling us the motives for putting the press to the labour of sweating in his writings.

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1. Cum multis vivorum dissectionibus animum ad observandum primum appuli, quo cordis motus usum & utilitates in animalibus per autopsiam, & non per libros invenirem; plane rem arduam reperi, ut motum cordis soli Deo cognitum esse, pœne opinarer. — Tandem majori indies, & disquisitione, & diligentia usus, multa viva introspidendo, multisque observationibus collatis, rem attigisse, & ex hoc labyrintho me extricatum evasisse, simulque motum,

Cajus's college, Cambridge, from whence he went out doctor, after having first spent about five years in the anatomical and medical emporium of that day, Padua, in Italy. After some practice, his merits appeared in the great judgment of Charles I. sufficient to entitle him the

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motum, & usum cordis, & arteriarum, quæna desiderabam, compertum habere me existimabam. Ex quo non solum privatim amicis, sed etiam publice in prælectionibus meis Anatomicis, Academico more, proponere sententiam non verebar.——Tandem amicorum precibus, par tim etiam aliorum per motus invidia, hæc typis mandare publice coactus fui. viz. an. 1628.——Iam denique nostram de circuitu sanguinis sententiam ferre, & omnibus proponere liceat.

2. Primum itaque aperto pectore, & dissecta capsula, cor immediate, observare licet, Cor aliquando moveri, aliquando quiescere; esse etiam tempus in quo movetur, & in quo motu destituitur.——In quiete, ut, in morte, cor laxum, flaccidum, jacet: In motu, erigatur cor, & in mucronem se sursum elevet; sic ut illo tempore ferire. Undique contrahi, magis vero secundum latera, ita ut, & longiusculum, & collectum appareat.——Ex his mihi videbatur manifestum; motum cordis esse secundum ductum omnium fibrarum constrictionem; secundum ventriculos coarctari, & contentum sanguinem protrudere; & eodem tempore pulsus forinsecus sentitur & contenti sanguinis protrusio cum impetu à constrictione ventriculorum.——Neque verum est, quod cor extentione sanguinem in ventriculos attrahere, sed dum laxatur & concidit, sanguinem ab auriculis recipere.

3. Eo tempore quo cordis fit Systole, (1.) arteriæ dilatantur, pulsum edunt, & in sua sunt Diastole. (2.) Quando sinister ventriculus cessat contrahi, cessat pulsus arteriarum. (3.) Item secta quavis arteria vel perforata, in ipsa systole ventriculi sinistri propellitur foras sanguis ex vulnere cum impetu.——Ex his manifestum, quod arteriarum Diastole fiat eo tempore, quo cordis systole.——Denique arteriarum pulsum fieri ab impulsu sanguinis è ventriculo sinistro, quo & pulsum æmulari, sive sint majores, vehementiores, frequentes, celeres; omnes enim rhythmum, quantitatem
&

the guardian of his health; and during the ſufferings of that prince, the doctor's perſon, writings, and eſtates, bore proportionably a large ſhare. His great genius at invention, and his anatomical ſkill, were not limited to the heart and generation only; but equally extended

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& ordinem ſervant cordis pulſantis. Quare pulſus arteriarum, nil niſi impulſus ſit ſanguinis in arterias.

4. Præter hæc obſervanda ſunt quæ ad auricularum uſum ſpectant, quorum duo ſunt auricularum, ventriculorum duo. Quatuor ſunt motus, loco, non vero tempore, diſtincti. Simul enim ambæ auriculæ moventur, & ſimul ambo ventriculi.—Duo ſunt motus, unus auricularum, alter ventriculorum: qui ſimul non ſunt; ſed præcedit motus auricularum, & ſubſequitur cordis; ut motus ab auriculis incipere, & in ventriculos progredi videatur.—Cum jam languidiora omnia, emoriente corde, inter hos duos motus, tempus aliquod quietis intercedit.—Sic prius deſinit cor pulſare quam auriculæ, ut auriculæ ſupervivere dicantur; primus omnium deſinit pulſare ſiniſter ventriculus, deinde ejus auricula, demum dexter ventriculus, ultimo (reliquis ceſſantibus ultimo) in dextra auricula vita remanere videatur.—Dum ſenſim emoritur cor, videre licet, poſt duas vel tres pulſationes auricularum, aliquando cor unum pulſum lente & ægre peragere & moliri. Ut hinc pateat quod in ventriculos ſanguis ingrediatur, non attractione, aut extentione cordis, ſed pulſu auricularum immiſſus.—Sed & præter hæc aliquoties à me obſervatum fuit (poſtquam cor ipſum, & ejus auricula etiam dextra, à pulſatione quaſi mortis articulo quieſcerent) in ipſo ſanguine qui in dextra auricula continetur, obſcurum motum, & undationem, ac palpitationem ſuperſuiſſe, tamdiu, quam calore imbui videretur. Tale quiddam evidentiſſime, intra ſeptem dies ab incubatione, in ovo, cernitur. In eſt primum ante omnia gutta ſanguinis, quæ palpitat ex qua incremento factò, fiunt cordis auriculæ; quibus pulſantibus, perpetuo ineſt vita. Tum etiam cordis corpus procreatur; ſed per aliquod tempus albidum apparet & exanguè, & immotum. Quinetiam in fœtu humano vidi,

circa

tended through the rest of the human fabric, that fell under his lectures, in the royal college of London, to which he was a liberal benefactor. But the rebellious devastations under his poor master, were here equally unmerciful to the learned, as they had been to the political world;

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circa principium tertii mensis, similiter cor formatum, sed albidum & exangue, cujus tamen auriculis sanguis inerat uberrimus & purpureus. Unde auriculum, prius quam cor ipsum vivere, & post etiam emori.

5. Ego ex his tandem & hujusmodi observationibus repertum iri confido, motum cordis ad hunc modum fieri. —Primum sese contrahit auricula, sanguinem contentum, in ventriculum conjicit; quo repleto, cor sese erigens, contrahit ventriculos, & pulsum facit: quo sanguinem continenter protrudit in arterias; dexter ventriculus in pulmones per vas illud, quod revera, & constitutione & officio, & in omnibus arteria est; sinister ventriculus in aortam, & per arterias in universum corpus. In istis cordis motibus, fit portionis sanguinis è venis in arterias ductio, & exaudiri in pectore contingit. —Motus itaque & actio cordis est ipsa sanguinis transfusio, & in extrema usque, mediantibus arteriis, propulsio; ut pulsus, quem nos sentimus in arteriis, nil nisi sanguinis à corde impulsus sit. —Quibus viis sanguis, è vena cava in arterias, vel è dextra ventriculo cordis in sinistrum deferatur. Fistulam sive arteriam, vel arteriæ analogon, aperte transmittere, tum visu, tum secta arteria (exinde sanguine singula pulsatione cordis profiliente) oculis palam confirmari posse constat. —Uti ex autopsia eodem modo è venis in arterias sanguinem pulsu cordis traduci, palam est: quæ via tam patens, aperta & manifesta, ut nulla difficultas, nullus hæsitandi sit locus.

6. Huc usque de transfusione sanguinis è venis in arterias, & de viis per quas pertranseat, & quomodo pulsu cordis, transmittatur dispenseturque. Nunc vero, de copia & proventu istius cum dixero; adeo nova erunt & inaudita, ut verear, ne habeam inimicos omnes homines. Tantum consuetudo, aut semel imbibita doctrina —Ani-
madverti

world; since, as the doctor assures us, they broke into his apartments during his absence, and destroyed those written fruits of his long labours and studies, that ought to have rendered perpetual honours to his immortal name, and services to all posterity. However, what he

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madverti tandem, venas inanitas & omnino exhaustas, & arterias ex altera parte, nimia sanguinis intrusione, disruptas fore; nisi sanguis aliqua via ex arteriis denuo in venas remearet, & ad cordis dextrum ventriculum regrederetur: unde cœpi egomet mecum cogitare, an motionem quasi in circulo haberet: quam postea veram esse reperi, & sanguinem, è corde per arterias, in habitum corporis & omnes partes, protrudi & impelli, à sinistri cordis ventriculi pulsu (quemadmodum in pulmones) & rursus per venulas in venam cavam, & usque ad auriculam dextram remeare; quemadmodum ex pulmonibus ad sinistram ventriculum, ut ante dictum est. Quem motum circularem eo pacto nominare liceat.—Sic contingit in corpore, partes omnes sanguine calido spirituoso (& ut dicam) alimentativo nutiri, foveri, vegetari; in partibus sanguinem refrigerari, coagulari, & quasi effœtum reddi; inde ad principium, videlicet cor, tanquam ad fontem reverti; ibi calore naturali, potenti, fervido, denuo colliquari; & spiritibus prægnantem, inde rursus in omnes partes dispensari.—Ita cor principium vitæ & Sol microcosmi appellari meretur, cujus virtute & pulsu sanguis movetur, perficitur, vegetatur, & à corruptione & grumefactione vindicatur, toti corpori fundamentum vitæ, auctor omnium.—His positis, sanguinem circumire, revolvi, propelli & remeare, à corde in extremitates, & inde in cor rursus, & sic quasi circularem motum peragere, manifestum puto.—Supponamus quantum sanguinis sinister ventriculus in dilatatione (quum repletus sit) contineat; ego in mortuo reperi ultra $\frac{2}{3}$ ij.—Supponamus similiter, quanto sese contrahit cor tanto minus continere, atque inde quantum sanguinis in arteriam magnam protrudatur: (protruditur in Systole enim aliquid semper, ex fabrica valvularum) verisimili conjectura ponere licet, in arteriam immitti partem quartam: ita in homine protrudi,

he has divulged upon the circulation through the heart, and the business of generation, are enough to show us the depths of his penetration, and the diligence of enquiry with which he always traced the steps of nature, in every part of the body ; as also of the ingenuity of his re-

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protrudi, singulis cordis pulsibus, supponamus $\frac{3}{4}$ sanguinis, qui, propter impedimentum valvularum, in cor remeare non potest.—Cor una semihora plus quam mille pulsus facit ; imo in aliquibus, & aliquando bis, ter, vel quater mille. Jam multiplicatis drachmis, videbis una semihora talem proportionatam quantitatem sanguinis, per cor in arterias transfusam ; quæ major est copia quam in universo corpore contingat reperiri. Similiter, in ove, aut cane, plerumque non continetur plus quatuor libris sanguinis ; quod in ove expertus sum. In quavis propulsione proportio sanguinis exclusi debet respondere quantitati prius contentæ, & in dilatatione replenti ; uti in contractione nunquam nihil vel imaginarium expellit, sed semper aliquid secundum proportionem contractionis. Quare concludendum, si uno pulsu in homine, cor emittat $\frac{3}{4}$, & mille fiant pulsus in una semihora, contingere eodem tempore, libras lb xlj, & $\frac{3}{4}$ viij, (si $\frac{3}{4}$ j, lb lxxxij & $\frac{3}{4}$ iiij) contingere in una semihora transfusas (inquam) esse de venis in arterias.—Interiam hoc scio, & omnes admonitos velim, quod aliquando uberiori copia pertransit sanguis, aliquando minore ; & sanguinis circuitus quandoque citius, quandoque tardius peragitur, secundum temperamentum, ætatem, causas externas & internas, & res naturales & non naturales, somnum, quietem, victum, exercitia, animi pathemata, & similia.—Arterias autem nullibi sanguinem è venis recipere, nisi transmissione facta per cor, ex antedictis, patet. Quare, ligando aortam ad radicem cordis, & aperiendo jugularem, vel aliam arteriam, si arterias inanitas & solum venas repletas conspexeris, mirari non convenit.—Hinc causam aperte videbis, cur in Anatome tantum sanguinis reperiatur in venis, parum vero in arteriis ; cur multum in dextro ventriculo, parum in sinistro ; causa forsan est, quod de venis in arterias nullibi datur transitus,

reflections in deducting their physiological and practical uses. As his great discoveries and doctrines of the circulation appeared plainly destructive of the whole foundation and fabric of medical theory, as it then stood tottering on the fancies of Aristotle and Galen; it accordingly

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nisi per cor ipsum & per pulmones.—Præterea hinc patet, quo magis, aut vehementius arteriæ pulsant, eo citius, in omni sanguinis hæmorrhagia, inanitum, iri, corpus.—Hinc etiam in omni lipothymia, omni timore & hujusmodi, quando cor languidius & infirmius, nullo impetu pulsat, omnem contingit hæmorrhagiam sedari & cohiberi.—Hinc etiam est, quod corpore mortuo, postquam cor cessavit pulsare, non possit, vel è jugularibus, vel cruralibus venis & arteriis apertis, ullo conatu, massæ sanguineæ plus quam pars media elici. Nec lanio, si bovi jugulum prius secuerit, totum sanguinem exhaurire inde poterit.—Hinc omnis tumoris causa (ut est apud *Avicen.*) & omnis redundantia opprimentis in parte; quia viæ ingressus apertæ, egressus clausæ, inde humorem abundare, & in tumorem partem attolli necesse est.—Hinc etiam contingat, quod, quousque tumor incrementum capefcit. Ego è curru delapsus aliquantum, fronte percussus, quo loco arteriæ ramulus è temporibus prorepit, statim ab ipsa percussione, spatio fere viginti pulsationum, tumorem ovi magnitudine, absque vel calore vel multo dolore, passus sum; propter videlicet arteriæ vicinitatem, in locum contusum, sanguis, affatim magis & velocius, impingebatur.—Hinc apparet, qua de causa phlebotomia, supra sectionem ligamus, non infra; quia per arterias impellitur in venas, in quibus regressus per ligaturam præpeditur, ideo venæ turgent, & distentæ impetu per orificium ejicere possunt; soluta vero ligatura, viaque regressus aperta, ecce sanguis non amplius, nisi guttatim decedit: & quod omnes norunt; si vel vinculum solveris vel stricte nimis constrinxeris, tum non exit, quia scilicet via, ingressus & influxus sanguinis per arterias, intercepta est stricte illa ligatura; aut regressus liberior datur, per venas, ligatura soluta.—Amplius observandum; quod in administranda phle-

ingly soon met with violent oppositions from the pens of several (otherwise learned and judicious) professors, who thought it but right, religiously to prostitute their sense and reason to the blind authorities of those fathers. Thus Riolan, and others at home, as well as abroad, stood

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phlebotomia quandoque contingat, hanc veritatem confirmari. Nam, recte brachium quanquam ligaveris, & scalpello debito modo diffecueris, apto orificio & omnibus rite administratis; tamen si timor, aut quævis alia causa, aut animi pathema lipopsychia adveniat, ut cor languidius pulset, nullo modo sanguis exhibit, nisi guttatim: præsertim si ligatura strictior paulo facta sit.—Ratio est, quia compressam arteriam languidor pulsus & impellens vis infirmior recludere & sanguinem infra ligaturam trudere non valet: imo per pulmones deducere, aut è venis in arterias copiose transferre, enervatum & languidem cor non potest.—Sic eodem modo, & eisdem de causis contingit mulierum menstrua, & omnem hæmorrhagiam sedari.—Ex contrariis etiam hoc patet; quoniam, redintegrato animo, amoto metu, cum ad se redeunt, jam adaucto robore pulsificante, arterias statim vehementius pulsare (etiam in parte ligata) in carpo moveri, & sanguinem per orificium longius proflire, continuo videbitur. [V. Lect. IV. per tot. & §. 115.].

7. Hactenus de copia pertranseuntis sanguinis in cor & pulmones, centrum corporis, & similiter ab arteriis in venas & habitum corporis. Restat, ut explicemus, quomodo per venas ab extremitatibus ad cor retro sanguis remeet, & quomodo venæ sint vasa deferentia eundem ab extremitatibus ad centrum: quo facto, tria illa proposita fundamenta pro circuitu sanguinis, fore aperta, vera, stabilia, & ad fidem sufficientia faciendam, existimamus.—Hoc autem, ex valvularum, quæ in venarum cavitatibus reperiuntur, usu, & ocularibus experimentis, satis erit apertum. Sunt namque in jugularibus deorsum spectantes, & sanguinem sursum prohibentes ferri: nam ubique spectant, à radicibus venarum, versus cordis locum.—Ego, ut alii etiam, aliquando reperi in emulgentibus & ramis mesenterii, venam cavam & portam spectantes. Sed omnino valvulæ hæc sunt,

stood many years insensible to all the convictions of plain reason, and the most cogent demonstrations by ocular experiments, merely that the blind authorities of Aristotle and Galen might not be over-turned, by this more certain and solid basis upon which medicine is at present

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sunt, ne, à venis magnis in minores, moveretur sanguis, & sic illas dilaceraret, aut varicosas efficerit; neve à centro corporis in extrema, progrederetur.—Ego illud sæpissime in dissectione expertus sum, si, à radice venarum initio factò, versus exiles ramos specillum immitterem (quanto potuerim artificio) ob impedimentum valvularum longius impelli non potuisse; contra vero forinfecus à ramulis radicem versus, facillime. Et pluribus in locis, valvulæ binæ ad invicem positæ & aptatæ sunt; adeoque venæ, viæ patentæ & apertæ sint, regredienti sanguini ad cor, progredienti vero à corde omnino oclusæ.

8. Comprehensa vena cava, sanguinisque cursu intercepto, per aliquod spatium infra cor, videbitur, à pulsu statim pœne inaniri illam partem intra digitos & cor; sanguine exhausto à cordis pulsu, simul cor albidiori multo colore esse; etiam in dilatatione sua, ob defectum sanguinis, minus & languidius tandem pulsare, sic ut emori denique videatur: cum contra statim, soluta vena, color & dilatationis magnitudo redeant cordi.—Postea si relinquas venam; & arterias similiter, per aliquam distantiam à corde, ligaveris vel compresseris; videbis contra, illas vehementer turgere in parte comprehensa, & cor ultra modum distendi, purpureum colorem contrahere usque ad livorem, & tandem opprimi sanguine, sic ut suffocatum iri credas: soluto vero vinculo, rursus ad naturalem constitutionem, in colore & magnitudine pulsus redire cerneris.—Ecce jam duo genera mortis; extincto ob defectum ad cordis dextrum & suffocatio ob copiam: hic ad oculos utriusque exemplum habere licet, & dictam veritatem autopsia in corde confirmare.—Sanguini itaque motu opus est, atque tali, ut ad cor rursus revertatur; nam in externas partes immotus coagularetur: motu enim in omnibus calorem generari & conservari videmus, quiete evanescere. Cum itaque sanguis

sent supported, and upon which she must ever hereafter rest, so long as nature herself shall endure. Others at length, that could not withstand their own eyes, and the just sentence of all Europe in its favour, were invidiously for depriving our British Hippocrates of the honours

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guis in externis partibus subsistens, à frigore extremorum & aeris ambientis geletur; ut rursus à fonte calorem omnino præ-servationem suam repetat, & revertendo redintegret necesse est.—Videmus, à frigore exteriori, extremitates aliquando algere, ut lividi & nasus & manus & genæ, quasi mortuorum, appareant; quia sanguis in ipsis (qualis cadaverum, locis pronis, solet decumbere) consistat: unde membra adeo torpida & ægre mobilia evadunt, ut vitam pene amisisse videantur. Nullo modo profecto rursus (præsertim tam cito) calorem, colorem & vitam recuperarent, nisi novo ab origine affluxu & appulsu caloris foverentur.—Hinc obiter petenda ratio est, cur mœrore, amore, invidia, curis & hujusmodi consectis, tabes & extenuatio contingant, aut cacochymia & proventus cruditarum, quæ morbos plurimos inducunt & homines conficiunt: omne namque animi pathema, quod cum dolore & gaudio, spe, aut anxietate humanas exagitat mentes, & ad cor usque pertingit, & ibi mutationem à naturali constitutione, intemperie & pulsu & reliquis facit, illud in principio totum alimentum inquinando & vires infirmando, minime mirum videri debet, quod varia genera morborum incurabili-um, in membris & corpore, subinde procreet; quando quidem totum corpus, in illo casu, vitiato alimento & inopia calidi nativi, laborat.—Præter hæc cum alimento vivant omnio animalia interius concocto, necesse est concoctionem perfectam esse, simul & distributionem; & proinde locum & conceptaculum, ubi perficiatur alimentum & unde derivetur in singula membra.

9. Sunt insuper problemata consequentia, ad fidem faciendam à posteriore non inutilia.—Videmus in contagione, ictu venenato, & serpentum aut canis rabidi morfu, in lue venerea, & hujusmodi, illæsa particula contacta, tamen totum habitum contingere vitiari: lues venerea, illæsis ali-

nours due from so great discoveries, by fishing them out from the dark waters of his predecessors; but all their arguments alledged, prove only that some imagined the blood had a kind of circularly returning motion within the vessels, in a manner to them unknown; or that they had only

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quando genitalibus, primo omnium vel scapularum, vel capitis dolore, vel aliis symptomatibus, sese prodere solet. Vulnere, facto à morfu canis rabidi, curato, febrem tamen & reliqua horrenda symptomata supervenisse experti sumus. Quoniam, in particulam impressum contagium, una cum revertente sanguine ad cor ferri & totum corpus postea inquinare posse, hinc patet. In tertianæ febris principio, morbifica causa cor petens, circa cor & pulmones quando immoratur, anhelosos, suspiriosos & ignavos facit; quia principium aggravatur vitale, & sanguis in pulmones impingitur, incrassatur, non transit (hoc ego ex dissectione illorum qui in principio accessionis mortui sunt, expertus loquor) tunc semper pulsus frequentes, parvi & quandoque inordinati sunt; ab adaucto vero calore, attenuata materia, apertis viis & transitu facto, incalescit universum corpus, pulsus majores fiunt & vehementiores, ingravescente paroxysmo febrili. Calor, scilicet præter naturalis, accensus à corde, inde in totum corpus per arterias diffunditur, una cum materia morbifica, quæ eo modo à natura exsuperatur & dissolvitur.—Cum etiam exterius applicata medicamenta vires intro exerceant suas, ac si intro sumpta essent, (colocynthis & aloe ventrem solvunt, cantharides urinas movent, allium plantis pedum alligatum expectorat & cordialia roborant, & hujus generis infinita) hinc constat forsan non irrationabiliter dici, venas per orificia, ab exterius admotis, absorbere aliquid & intro cum sanguine deferre, non alio modo, quam illæ in mesenterio, ex intestinis chylum exfugunt & ad jecur una cum sanguine apportant.—Plant-animalia dicta, Ostrea, Mytili, Spongiæ & Zoophytorum genera omnia, cor non habent; pro corde enim toto corpore utuntur, & quasi cor, hujusmodi animal est. Cor recte discernere attamen in apibus, muscis, crabronibus & hujusmodi aliquando (ope perspicilli) licet.

ly begun to form a loose idea of the mode, in which a little part of the circulation was effected (See §. 62. following); nor was any of those obscure passages noticed by Dr. Harvey, who proposed the tracing of nature herself, and experimenting on living brutes, as the

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licit.—Pulsans quiddam intueri, etiam in pediculis, in quibus & transitum alimenti per intestina (cum translucidum sit animal) instar maculæ nigræ cernere insuper clare poteris, multiplicantis illius specilli ope.—Sed in exanguibus & frigidioribus quibusdam, ut cochleis, conchis, squillis crustatis & similibus inest pulsans particula, quasi vesicula quædem vel auricula sine corde, rarius contractionem faciens, & quem non, nisi æstate aut calidiori tempestate, discernere licet: in his pulsu aliquo opus est, ad alimenti distributionem, propter partium organicarum varietatem, aut densitatem substantiæ: sed rarius fiunt pulsationes, & quandoque omnino non, ob frigiditatem.—Hoc etiam infectis videtur contingere, cum hyemæ lateant, vel plantæ vitam tantummodo agant: sed an idem etiam quibusdam sanguineis animalibus accidat, ut ranis, testudinibus, serpentibus, hirundinibus, non injuria dubitare licet. Unde & verissimum illud (*Aristot. de part. animal. 3.*) quod nullum sanguineum animal careat corde.—Sic quibuscunque insunt pulmones, illis duo ventriculi cordis, dexter & sinister; & ubicunque dexter, ibi sinister quoque inest; non è contra. Cum spongiosi, rari & molles sint ipsi pulmones, ad protrusionem sanguinis per ipsos vim tantam non desiderant; proinde in dextro ventriculo fibre, pauciores & infirmiores, nec ita carnosæ, aut musculos æmulantes: in sinistro vero sunt robustiores & plures, carnosiores & musculosi; quia sinister ventriculus majori robore & vi opus habet, quo per universum corpus longius sanguinem prosequi debet. Hinc etiam medium cordis possidet, & triplo crassiorē parietem & robustior est sinister ventriculus dextro. Hinc omnia animalia, etiam homines, quo densiori, duriori & solidiori habitu sunt carnis, eo magis fibrosum, crassum, robustum & musculosum habent cor.

10. Valvularum similiter usum considera; quæ ideo factæ,

the sole rules to guide his disquisitions. Thus if it be plain, that Hippocrates and some others have known and declared, that there was both a circulation and a perspiration throughout the body; 'tis equally evident, from their writings, that they neither knew the antecedent causes, the

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ne semul emissus sanguis in cordis ventriculos regeratur. Differentia ventriculorum incipit in robore, quia dexter duntaxat per pulmones, sinister per totum corpus impellit. — In aliquibus hominibus, torosis videlicet & durioris habitus, dextram auriculam ita robustam, & cum lacertulis & vario fibrarum contextu intius affabre concinnatam reperi; ut aliorum ventriculis robore videretur æquipollere: & mirabar fane quod in hominibus diversis, tanta esset differentia. — Sed notandum, quod in fœtu auriculæ longe majores, quam pro proportionem infunt; quia, antequam cor fiat, aut suam functionem præstet, (ut ante demonstratum est) cordis quasi officium faciunt. Primum, dum fœtus, quasi vermiculus mollis, inest solum punctum sanguineum, live vesicula pulsans, & umbilicalis venæ portio, in principio vel basi dilatata: postea cum fœtus delineatus, ista vesica carnosior & robustior facta in auriculas transit, super quas cordis corpus pullulare incipit, nondum ullum officium faciens publicum: formato vero fœtu, cum jam distincta ossa à carnibus sunt, & perfectum est animal & motum habere sentitur, tum cor quoque, intus pulsans habetur, & (ut dixi) utroque ventriculo sanguinem è vena cava in arteriam transfundit. — Sic natura divina, cor addidit gradibus, transiens per omnium animalium constitutiones ut ita dicam, ovum, vermem, fœtum, &c. Arteriæ in sua tunicarum crassitie & robore tantum à venis differant, quia sustinent impetum impellentis cordis & prorumpentis sanguinis. — Hinc, cum natura perfecta nihil facit frustra, & in omnibus sit sufficiens; quanto arteriæ propinquiore cordi sunt, tanto magis à venis in constitutione differunt, & robustiores sunt & ligamentosæ magis; in ultimis vero disseminationibus ipsarum, ut manu, pede, cerebro, mesenterio, spermaticis, ita constitutione similes sunt, ut oculari tunicarum inspectione, alterum ab altero internoscere difficile

the modes of operation, nor the immediate effects of them; which, as Dr. Pitcairn has, in his vindications, amply and elegantly proved, make the essential parts of every scientific discovery.

§. XIX. The publication of Dr. Harvey's great discovery to the world, soon excited a spirit

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cile fit. Hoc autem iustis de causis sic se habet; nam quo longius arteriæ distant à corde, eo minore multo vi, ictu cordis per multum spacium refracto, percutiuntur.—Adde, quod cordis impulsus, cum in omnibus arteriarum truncis & ramulis sufficiens sanguini esse debeat, ad divisiones singulas quasi partitus imminuitur: adeo ut ultimæ divisiones capillares arteriosæ videantur venæ, non solum constitutione, sed & officio & sensibilem pulsum aut nullum aut non semper edant, nisi cum pulsat cor vehementius, aut arteriola in quavis particula dilatata aut aperta magis est. Inde fit ut in dentibus quandoque & tuberculis, quandoque in digitis sentire pulsum possimus, quandoque non. Unde pueros (quibus pulsus semper sunt celeres & frequentes) hoc uno signo febricitare certo observavi; & similiter in tenellis & delicatulis, ex compressione digitorum, quando febris in vigore esset, facile ex pulsu digitorum percipere potui.—Ex altera parte, quando cor languidius pulsatur, non solum, non in digitis, sed nec in carpo aut temporibus pulsum sentire contingit, ut in lipothymia, hysterice symptomatibus, asphyxia, debilioribus & morituris.—Eodem modo in pulsum speculatione; cur videlicet isti lethales, aut contra; & in omnibus generibus, ipsorum causas & præagia contemplando, quid isti significant, quid hi, & quare.—Similiter in crisis & expurgationibus naturæ, in nutritione, præsertim distributione, alimenti, similiter & omni fluxione.—Denique in omni parte medicinæ, Physiologica, Pathologica, Semeiotica, Therapeutica, cum quot problemata determinari possint ex hac data veritate & luce; quanta dubia solvi & quot obscura dilucidari, animo mecum reputo, campum invenio spatiosissimum, ubi longius percurrere & latius expatiari adeo possum, ut non solum in volumen excresceret, præter institutum

ſpirit of emulation, and employed all the European profeſſors of anatomy, to trace the ſteps thereof, both in living and dead ſubjects; and in both to examine all parts with more labour and care than they were hitherto uſed to beſtow: the conſequences of which were, very confi-

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inſtitutum meum, hoc opus, ſed mihi forſan vita ad finem faciendum deficeret.

II. Quantum pulmones in textura & mollitie, ab habitu corporis & carnis recedunt, tantum differt venæ arterioſæ tunica, ab aortæ. Semper hæc omnia ubique proportionem ſervant, in hominibus: quanto enim magis toroſi, muſculoſi & durioris ſint habitus, & cor habeant robuſtum, craſſum, denſum & fibroſum magis, tanto auriculas & arterias proportionabiliter in omnibus, craſſitie & robore habent magis respondentes. Hinc quibus animalibus, leves ventriculi cordis intus ſunt, abſque villis aut valvulis, & pariete tenuiore (ut piſcibus, avibus, ſerpentibus & quam pluribus generibus animalium) in illis arteriæ parum aut nihil à venis differunt in tunicarum craſſitie. Amplius, pulmones tam ampla habent vaſa, venam & arteriam, ut truncus arteriæ excedat utroſque ramos crurales & jugulares; cauſa eſt, quia in pulmonibus & corde promptuarium, fons & theſaurus ſanguinis & officina perfectionis eſt.——*Vita igitur in ſanguine conſiſtit*, (uti etiam in *ſacris noſtris* legimus). Crebrâ enim (ut dixi) vivorum diſſectione expertus ſum, moriente jam animali, nec ampliùs ſpirante, cor tamen aliquandiu pulſare, vitâque in ſe retinere. Quiſcente autem corde, motum videas in auriculis ſuperſtitem, ac poſtremò in auricula dextrâ; ibique tandem ceſſante omni pulſatione, in ipſo ſanguine undulationem quandam, & obſcuram trepidationem, ſive palpitationem (extremum vitæ indicium) reperiâs. Et cuilibet cernere eſt, ſanguinem ultimo calorem in ſe retinere: quo ſemel prorſus extincto, ut jam non ampliùs ſanguis eſt, ſed *cruor*; ita nulla poſſliminio ad vitam revertendi ſpes reliqua. At verò, tum in ovo, tum in moribundis animalibus, poſtquam omnis pulſatio diſparuit; ſi vel puncto ſalienti, vel dextræ cordis auriculæ levem ſomiteꝝ admoveris; videbis illico, motum, pulſationem, ac vitam

considerable anatomical discoveries, of a lesser order, by different professors, in all quarters of Europe; according as each of them had chosen particular provinces of the human body, to be the proper objects of their stricter enquiries and experiments. Injections of water, milk, ink, &c.

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à sanguine redintegrari: modo is calorem omnem innatum, spiritumque vitalem haud penitus amiserit.—*Quibus clarè constat, sanguinem esse partem genitalem, fontem vitæ, primum vivens & ultimo moriens, sedemque animæ primarium; in quo (tanquam in fonte) calor primò, & præcipuè abundat, vigetque; & à quo reliquæ omnes totius corporis partes calore influente foveantur, & vitam obtinent.*—Propterea sanguis ubique in corpore reperitur; nec uspiam id acupungere, vel minimùm scalpere queas, quin sanguis ocyùs profluat: tanquam, absque eo foret, nec calor partibus, nec vita superesset, Ideòque, concentrato, fixòque leviter sanguine (*Hippocrates, ἀπόληψιν τῶν φλεβῶν*, nominavit) veluti in lipothymia, timore, frigore externo, & febrium insulta contingit; videas illico totùm corpus frigescere, torpere, & pallore livorèque perfusum languescere: evocato autem rursus sanguine, per adhibita fomenta, exercitia, aut animi passiones, (gaudium nempe, iramve) hui! quàm subito omnia calent denuo, florent, vigent, splendentque? hinc causas perspicere liceat, non modò vitæ, in genere, sed longioris etiam, aut brevioris ævi; somni, vigiliarum, ingenii, roboris, &c. Nanque *eius tenuitate* (ait ibid. *Arist.*) & *munditie, animalia sapientiora sunt, sensumque mobiliorem obtinent: Semiliter, vel timidiora, vel animosa; iracunda, & furiosa evadunt; prout scil. sanguis eorum vel dilutus, vel fæcis multis crassisque refertus fuerit.*—Nec vitæ solùm sanguis autor est; sed, pro ejus vario discrimine, sanitatis etiam, morborumque causæ contingunt. Quinetiam venena, quæ forinsecus nobis adveniunt (ut ictus venenati) nisi sanguinem inficerent, damnum nulum afferrent. Adeò nobis ex eodem fonte, vita & sanitas profluunt. Si sanguis nimis eliquescat (inquit *Arist.*) *aggravant.* Namque in cruorem serosum abit adeò, ut quidam sudorem cruentum exsudârint.—*Aristoteles quoque, ut sanguinem*

&c. were first used to trace the vessels, by Eustachio, Harvey, Highmore, Glisson, Willis, Bartholin, &c. which were afterwards changed for suet, or other hardening matters, by the ingenious Swammerdam; from whom his friend Ruysch received them, and by their dexterous administration,

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guinem alendi gratiâ institutum putavit; itâ eundem etiam, veluti è partibus, compositum censuit. Nempe ex crassiore, & atrâ, quæ in fundum pelvis, inter concrescendum, subfidit: eâque pars illi deterior habetur: *Sanguis enim*, inquit, *si integer est, rubet, & dulcis saporis est; sed, si vel naturâ, vel morbo sit vitiat, atrior cernitur.* Ex parte etiam fibrosâ, sive fibris, constare voluit: *isq; demptis*, (ait) *sanguis neque concrescit, neque spissatur.* In sanguine præterea saniem agnovit: *Sanies*, inquit, *sanguis incoctus est; aut quia nondum percoctus, aut quod in seri modum dilutus fuerit.* Atque hunc frigidorem esse, ait; *fibras autem partem sanguines terrenam esse statuit.*—Quapropter sanguis variè discrepat: adeò ut quibusdam is sit serosior, tenuior, & quasi sanies, seu ichor ut in frigidioribus; quibusdam verò crassior, fibrosior, & terrestrior, &c. nonnullis (vitiati scil. temperamenti) sanguis atrior: aliis autem mundus, sincerus, & floridus, qualis præcipuè conspicitur. —Unde constat, tum *Medicos*, tum *Aristotelem*, sanguinem ex partibus & differentiis quadantenus similibus constitutere. Quippe priusquam corporis quispiam visu discernitur, sanguis jam genitus & actus est, *palpitâtque* (ut *Aristoteles*, ait) *intra venas, pulsûquo simul quoquoersum movetur; solûsque omnium humorum sparsus per totum corpus animalium est.* Et semper, *quandiu vita servatur, fervet.* Quinimo ex vario ipsius motu, in celeritate aut tarditate, vehementiâ aut debilitate &c. eum & irritantis injuriam, & foventis commodum persentiscere, manifestum est. Quippe sanguis, dum in corpore naturaliter se habet, similis ubique constitutionis apparet. Quamprimùm autem extravasatur, caloremque nativum exuit; protinus, (ceu dissimulare quiddam) in diversas partes abit. Partes porrò aliæ fibrosæ & densiores (reliquarum vinculum:) aliæ serosæ, quibus coagulatus thrombus innatare solet. Atque in

tion, with other artifices, acquired no small degrees of profit, and extensive reputation; the magnifier or microscope, began also to be first applied to anatomy by Dr. Harvey *, and by the two last gentlemen. Dr. Harvey first published upon the motion of the heart and blood, at Franc-

* See his observations on the heart of insects. p. lxx. sub finem.
fort,

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hoc serum, sanguis tandem fere totus degenerat. Partes autem istæ non insunt vivo sanguini, sed à morte solum corrupto, & jam dissoluto. In calidioribus & robustis hominibus alia sanguinis pars cernitur quæ in eo foras oducto & grumescente superiorem locum occupans condensatur, & gelatinem ex cornu cervino, seu mucaginem quandam, aut albumen ovi crassius planè refert; locumque supremum in sanguinis disgregatione obtineat.——Deinde in venæ sectione, sanguis hujusmodi profiliens (qui plurimus abundat hominibus calidæ temperaturæ, robustis, & torosis) longiore filo impetûque vehementiore (tanquam è siphone elusus) exsilit: ideoque eum calidiorem, & spiritalem magis judicamus; quemadmodum & genitura foecundior, spiritibusque plenior æstimator; quæ longe, validèque ejicitur.——Differe quoque plurimum hanc mugaginem, ab ichoroso & aquosâ illâ sanguinis parte, quæ (ceu reliquis frigidior) aquosa & saniosa pars, crudior magisque incocta est, quàm ut in puriorem & perfectiorem sanguinem transire possit. Quin certum est, non modò partem, illam, sed & universum sanguinem, in saniam ichorosam corrumpi posse. Resolvuntur nempe in materiam, unde primo componebantur; ut sal in lixivium, unde orus est. Similiter in omni cachexiâ, sanguis emissus copioso sero abundat: adeò, ut interdum vix quicquam grumosi appareat, sed omnis sanguis una sanies videatur: sicut in leucophlegmatia experimur, & animalibus exsanguinibus naturale est. Virginibus cachecticis, febrique albâ laborantibus, ut reliquo earum corpori, ità jecori etiam pallidus inhæret color; penuriæ sanguinis in corpore manifestum indicium.——Dum autem assero, vitam primò ac principaliter in sanguine residere: nollem hinc perperam concludi, omnem phlebotomiam esse periculosam, aut noxiam: vel, cum vulgo, credi, quantum sanguinis detrahatur, tantundem si-

mul

fort, 1628; about which time, Afelli of Milan, also published his discovery of the lacteals in a dog. Pecquet of Paris, wrote on the receptacle and duct of the chyle (1651.), that had been described before him by Eustachio. Bills and Jollif espied the lymphatic vessels

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mul vitæ decedere; quòd sacræ paginæ, vitam in sanguine constituerint. Quotidianâ enim experienciâ notum est, sanguinis missionem esse plurimorum morborum salutare auxilium, & inter remedia universalia præcipuum: utpote ejus vitium, vel abundantia, maximam morborum catervam constituat; & oportuna evacuatio, à morbis periculosis, mortêque adeò ipsâ sæpe liberet. Quantum enim sanguinis ex arte detrahitur, tantundem vitæ ac salutis additur.—Id ipsum nos Natura docuit, quam Medici sibi imitandam proponunt: hæc enim, largâ & criticâ evacuatione per nares, menstrua, aut hæmorrhoidas, affectus sæpe gravissimos tollit. Ideòque adolescentes, qui pleniore victu utuntur, vitamque in otio transigunt, nisi circa decimum octavum, aut vicesimum ætatis annum (quo tempore sanguinis copia, unâ cum corporis incremento accumulari solet) aut spontaneo per nares, vel loca inferiora effluvio; aut apertâ venâ, à sanguinis onere liberentur; plerunque febribus, variolis, capitis doloribus, aliisque morbis & symptomatis gravioribus periculosissimè ægrotant. Quod respicientes *Veterinarii*, omnem ferè jumentorum medelam à venæ sectione auspicantur. Ultimo jam experimentum hoc admirabile (unde cor ipsum, membrum scilicet principalissimum, vix sensile appareat) non reticemus.—Nobilissimus Adolescens, & illustrissimi Vicecomitis de Montegomero in Hibernia filius primogenitus, cùm adhuc puer esset, ingens ex insperato lapsu nactus est infortunium; costarum nempe sinistri lateris fracturam. Abscessus suppuratus, magnam tibi quantitatem profudit; saniesque diu è cavitate amplissimâ manavit: uti ipse mihi, aliisque (qui aderant) fide digni narrârunt. Is circa annum ætatis suæ decimum octavum, aut decimum nonum, per Galliam & Italiam peregrinabatur; indeque Londinum apulit. Interea verò peramplum hiatus in pectore apertum

vessels (1650.); which had been transiently seen upon the liver before them, by Aselli. Wharton (1656.), Steno (1662.), and Nuck (1690.), dived into the glandules in general. Swammerdam (1664.), and de Graaf (1668.), examined the parts of generation; Harvey (1651.),

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tum gestabat; adeò, ut pulmones (uti creditum est) in eo cernere, ac tangere liceret. Id cum serenissimo *Regi Carolo*, ceu miraculum, nunciaretur; me statim, ut quid rei esset perspicerem, ad Adolescentem misit. Quid factum? Cum primùm accederem, viderémque juvenem vegetum, & aspectu quoque, habitúque corporis laudabili præditum; aliquid secus, atque oportuit, nunciatum arbitrabar. Præmissâ autem, ut mos est, salutatione debitâ, expositâque ex mandata Regis eum adeundi causâ; omnia illico patefecit, nudâmque lateris sinistri partem mihi aperuit; ablatâ scilicet lamellâ, quam tutelæ gratiâ adversus ictus, aliâsque injurias externas, gestabat. Vidi protinus ingentem pectoris cavitatem, in quam facilè tres meos priores digitos, unâ cum pollice immitterem: simulque in primo ejus ingressu partem quandam carnosam protuberantem, reciprocoque extrorsum introrsumque motu agitatam deprehendi, manúque cautè tractavi. Attonitus rei novitate, iterum iterumque exploro omnia: &, cùm diligenter satis investigata essent; certum eram, ulcus antiquum & peramplum (citra Medici periti auxilium) miraculi instar, ad sanitatem perductum esse, parteque interiore membranâ vestitum, & per marginis ambitum firma cute munitum. Partem autem carnosam (quam ego primo intuitu, carnem aliquam luxuriantem credideram, aliique omnes pulmonis partem judicabant) ex pulsu, ejusque differentiis, seu rhythmo, (utrisque manibus carpo & cordi simul admotis) & ex respirationis collatione planè perspexi, non pulmonis lobum aliquem, sed cordis conum esse; quem caro fungosa excrecens (ut in fordibus ulceribus fieri solet) exterius, munitis instar, obtegebat. Concamerationem istam, à subnascentibus foribus Adolescentis famulus injectionibus tepidis quotidie liberabat, laminâque imponebat: quo facto, herus sanus, & ad quælibet exercitia ac itinera promptus, tutò & jucundè vitam degebat.—Responsum vice igitur,
Ado-

(1651.), Needham (1666.), Hoboken (1669.), and Kerkring (1670.), the foetus, and its appertinents. Gliffon illustrated the liver (1654.); Verſung (1643.), and de Graaf (1664.), the pancreas; Ruysch (1665.), the ſpleen and lymphatics; Willis (1664.), Vieufens (1685.), and Ridley (1695.), the brain and nerves, while Ruysch went on with the blood-veſſels. Willis (1673.), and Peyer (1677.), ſcrutinized the ſtomach and guts; Bellini (1662.), and Malpighi (1666.) the kidneys; Borelli, and Lower (1669.), the heart; Highmore (1651), Schneider (1655.), and Cowper (1698.), the inner nares; Briggs, the eye (1685.), and Duverney (1683.), the organs of hearing, &c. all which, with leſſer diſcoveries and obſervations, you will find worked up into the ſystems of the laſt age, recommended at §. XIII. although, as we have before obſerved (§. XVI.), you will perceive a great many of thoſe ſuppoſed new diſcoveries, already anticipated above an age before, by the great prince

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Adoleſcentem ipſum ad ſereniſſimum Regem deduxi; ut rem admirabilem & ſingularem, propriis ipſe manibus tractaret, atque oculis intueretur: nempe, in homine vivente & vegeto, citra ullam offenſam, cor ſeſe vibrans, ventriculoſque ejus pulſantes videret, ac manu tangeret. Factumque eſt, ut ſereniſſimus Rex, unà mecum, cor ſenſu tactus privatum eſſe agnoſceret. Quippe adoleſcens, nos ipſum tangere (niſi viſu, aut cutis exterioris ſenſatione) neutiquam intelligebat. — Simul, cordis ipſius motum obſervavimus; nempe, illud in diaſtole introrſum ſubduci & retrahi; in ſyſtole verò, emergere denuo & retrudi: ſerique in corde ſyſtolen, quo tempore diaſtole in carpo percipiebatur: atque proprium cordis motum & functionem, eſſe ſyſtolen: denique, cor tunc pectus ferire, & prominulum eſſe; cùm erigitur ſurſum, & in ſe contrahitur.

prince of anatomists, Eustachio. See §. XVI. foregoing.

§. XX. Those who desire to be still better critics in the anatomy and physiology of the present day, beyond the lengths which our present Compendium will conduct them, may consult our learned anatomist, Dr. Haller's notes on Boerhaave; for the sake of form, those reprinted at Venice, 4to. seven vol. 1741. & seq. to which add the eight supplemental volumes of Theses, intended to supply their defects, lately imported by Mr. Nourie, in the Strand. The learned *Adversaria* and *Epistles* of that great ornament to anatomy, and to all Italy, Morgagni; the improved system of Winslow, that is daily expected from under the care of Dr. Astruc; the works of Albinus and Ruych, &c. The principal writers from Hippocrates to Harvey may be briefly surveyed in the *Bibliographia Anatomica* of Dr. Douglas. Lug. Bat. 1727. L. Heisteri. * *Compend Anat.* Amst. 1750. For figures, those of Eustachio, explained by Albinus, Leidæ, 1744. Those pompous tables, which are by some ascribed to Swammerdam, first published with a bad explanation; by Dr. Bidlow, and afterwards with a better, by Mr. Cowper, are so finelly designed, by Laireffe, and engraved by Van Gunst, that the fair copies of them will hardly ever fail of esteem, although they fall very short of anatomical truth. Many of the figures are inverted, so

* See also his *Oratio de incrementis anatomie in hoc seculo XVIII.* and *Georgii Frankii Bona nova anatomica superioris seculi inventa*, 4to. Heidelberg. &c.

that you cannot see them rightly, but by looking at them in mirror; as those of the heart and lungs, tab. 22. and 24. also of the liver, tab. 37. The figures, no less than the vascular and nervous structure of the viscera, are often very wide of nature; sometimes supplied from fancy, and bad preternatural figures. But the muscles are fine, strong, and lively; the general situations of the viscera, in the venters, well represented, and the bones are no less beautiful: only as the muscles are sadly dissected or prepared, for the draughts, so the bones are copied from bad specimens, such as are too smooth, young, female, or unexercised, yielding no just ideas of the asperities, by which the muscles are inserted into them.---Those, on the contrary, which have been given us by the great Eustachio of our age, Albinus, are every way finished to perfection, so as to represent even the very habits of the foetal and adult bones and muscles, as in a painting: and those figures of the viscera, that are now publishing in numbers, by a very learned anatomist, author of this treatise, Dr. Haller, at Gottingen, in Germany, are equally finished and praiseworthy; as are also the plates of the gravid womb, now in the press, by the ingenious Mr. Hunter. The muscular system, printed in colours at Paris, by M. Gautier, 1745. & seq. fall very short of those that were published by Courcelles, (*icones musculorum Capitis Leidæ*, 1743.), which show us that Le Blond's art of printing things to the life by a due mixture of the primitive colours, red, blue and yellow, may both

both elegantly and usefully be applied to anatomy; as Dr. Martin of Chelsea, has formerly shown us in Botany. Those who desire truth and cheapness together, can purchase no set of anatomical figures, equal to those of Eustachio and Albinus, lately published by Mess. Knaptons, in Ludgate-street; but bad figures, like bad habits in music or other sciences, ought carefully to be shunned by all learners in anatomy, as they corrupt the ideas, or fix impressions that are afterwards not easily corrected, but from viewing nature herself, under a good professor.



4 FE 64

PHYSIOLOGIA;

O R, A

COURSE of LECTURES

O N T H E

VISCERAL ANATOMY and LIVING
OECONOMY of the HUMAN BODY, &c.

LECTURE I.

Of the Animal Fibres.

§. I. **T**H E most simple parts of the human body are either fluid or solid. The fluid parts being of divers kinds, we shall hereafter consider in their most convenient places. But here the solids, which make the most simple and true basis of the body, come first to be considered before the history of the other parts.

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R E M A R K.

A *body*, philosophically speaking, is any extended and resisting object of our senses; whose parts have more or less an attractive and cohesive force one to another. If this cohesion betwixt the parts are strong enough to keep them in their situations (contrary to the force by which they tend to the earth's center) and preserve the natural figure of the body, we call it a *solid*; but if this cohesion be so weak that the gravitation of parts brings them to a level, or to a portion of the earth's convexity, when left to themselves, we call it a *fluid*; but if the cohesion of parts be neither strong enough to retain the figure, nor weak enough to let them flow to a level, we call the body *soft*, in various degrees 'till you come to the cohesion of a solid, beyond which we count *hardness*. Hence we see, that, by lessening the cohesion and contact of parts, the same body may be either solid, soft or fluid; as, e. g. Resin or butter with different degrees of heat, lessening the attraction of cohesion in the constituent particles.

§. 2. The solid parts of animals and vegetables have this fabric in common, that their elements, or the smallest parts we can see by the finest microscope, are either fibres, or an unorganized concreat.

R E M A R K.

(1.) Elements are the smallest and most simple particles we can descend to in the composition of bodies. And these, which we are to consider as the keys of nature, are such as we are either led to by sense and reason, or by reason
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son only. These last are, therefore, termed ontological elements or primitive atoms, from their first observer Democritus, in contradistinction to the four common or physical elements of Aristotle. For though matter be in the mind infinitely divisible, 'tis not actually so in nature, but to a certain degree. And from these indivisible or atomical particles, differing only in bulk and figure, by a various combination, arise those sensible or universally extended homogeneous bodies we call physical elements, because we see nature uses them by mixture, texture and organization to form all the bodies in the universe. Such are the infinite expansion of *æther*; our limited sphere of *air*; the more confined body of *water*; and that still less body which we call *earth*.

(2.) *ÆTHER* is that compound, ever highly elastic and subtilest of all fluids, which is extended by reciprocal undulations throughout the universe (our vacuum's or exhausted glasses not excepted) so as (by moving with a certain celerity in direct lines) to form *light*; by reflection and refraction, *colours*; by attraction and collision with the other elements, *heat* and *fire*, less degrees of which we call *cold*.

(3.) *AIR* is that diaphanous and compressible fluid which is extended about a degree round the terraqueous globe, being with us about 46,656,000,000 times more dense and sluggish than *æther*, betwixt which and air there is a very great affinity or attractive force, as their density; i. e. the air contiguous to the *æther* takes in and concentrates the *æther* proportionally to its greater density, by which it is rendered more springy and active, with this difference that the air, by contact and cohesion in the parts of bo-

dies, becomes solid and unelastic (but æther never); from whence again, by heat, fire or dissolution of parts being separated, its elasticity returns. This element has a near affinity or relation to water, because it eagerly takes up rarified water into itself, as water again drinks up a portion of air within its contact; so that air and water, actuated by æther, make the levers and wedges by which nature performs all her changes in bodies either synthetically or analytically. And it serves as the common medium of communication betwixt us and all bodies.

(4.) WATER is a colourless, insipid, inodorous and unflammable liquor, strongly related or of near affinity both to air and earth, but more particularly the last, since it readily absorbs them, as they absorb it. This owes it fluidity to a certain degree of heat, since with a heat, two thirds less than that of our blood, it congeals; and with about twice the heat of our blood it boils, beyond which it can be made no hotter.

(5.) EARTH, as an element, is a solid, opaque, angular, friable, chalky substance of such small volatile particles, that it readily diffuses itself through air and water, and resides invisibly in them; as earth eagerly imbibing both air and water, by their means forms the permanent basis and growth of all mineral, vegetable and animal bodies.—A small particle of æther, air and water combined will, from their fluidity, form a spherule, consequently insipid and inodorous; but coming into strict union, round a more dense, angular particle of earth, will be a conoide corpuscle, of which the spherule will be the basis, and the least point of the earth the apex. Such a particle, irritating the smell and taste by its
figure

figure and density, volatile from its minuteness, and strongly attracting both air, water, and earth, (especially the last) we call an acid, fluid salt. And such parts again variously combined with light earth and the other elements, will form a bituminous, greasy, sulphurous or oily substance, combustible or inflammable, as Sir I. Newton observes. Thus mineral elements, salts and sulphurs taken from the earth, do, by heat and organisation, become vegetable in plants; those of plants are changed into animals, and those of animals into one another, without ever carrying the dissolution to the minima naturalia, or atoms of Democritus. An acid is thus by the reed neutralised into sugar; in the common radish, pellitory of the wall, &c. 'tis made nitrous; in the horse-radish, onion, &c. alkaline; and alcalies, (foot, pot-ash, rotten flesh) are again in the vine and grape changed first into a sour and then into a saccharine juice, &c. so that out of a few simple elements (as in the notes of music) by combinations arise all the varieties of medicinal and other substances. These combined by mere mixture and contexture, as in minerals, salts, gums, cartilages, glue, &c. make an unorganised concreat; but when the parts combined perform any motion in a living body, whether plant or animal, we call them a machine, or if complex an organ; of which fibres or flexible elastic threads are the most simple, and universally compose the rest. So elastic globules, with a watry albumen or gelly, are the basis of all the circulating juices, that of the nerves not excepted.

§. 3. A fibre in general may be mathematically considered as resembling a line made

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of points, having a moderate breadth ; or rather geometrically as a slender cylinder. And that the more constant or permanent parts thereof are earth, is demonstrated from a calcination, or a long continued putrefaction.

R E M A R K.

An animal or human body is not improperly said to be made up of clay or slimy earth, since all the solids (which are composed of fibres) and even the permanent or globular fluids which circulate, are formed of chalky particles like those of pipe clay cemented together by glue or gelly ; as you may see by burning a lump of blood or a bone in a clear fire, where after the air, water, salt and oil, which compose the glue, are expelled and consumed, you have a white, friable, chalky earth, coming the nearest to virgin or elementary earth of any we know. So likewise by disease or putrefaction in a spina ventosa of the bones. And we see these *stamina* or gluey particles of earth, which compose all the minute, solid and fluid machinulæ of the body, are prepared from our ingesta passing not only the chylicative, sanguineous and serous vessels, but also for some parts through the brain and nerves, before they are applied as nutritious matter ; requiring a healthy strong state both of vessels and humours to duly prepare them as to size, quantity and quality, as well as to apply them, (a defect of which we see in rickets, scorbutic, venereal, cases) ; whence 'tis somewhat strange our great Boerhaave should in his 21st practical aphorism, conceive them as immutable in their soft glutinous state within our bodies, as
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in the dry rigid condition of a goldsmith's cup-pell, after passing the fire.

§. 4. These earthy particles have their connexion and power of cohesion not from themselves, or a mere contact, but from the intermediate glue placed betwixt them. This we know from the experiments mentioned above (§. 3.); and from the easy experiment by which a burnt hair, whose parts yet hang together, recovers a degree of firmness by dipping in water or oil. Also the remains of ivory or bone shavings, whose gelly has been extracted, become friable.

R E M A R K.

These experiments sufficiently prove that the degree of cohesion in the parts of a fibre by which 'tis said to be strong or weak, lax or rigid, depends chiefly on the quantity and tenacity of the intermediate connecting glue.

§. 5. That this glue is composed of oil combined with water by the vital attrition in animals, appears again from the chemical analysis of bones and hair; from the jelly of bones, ivory, and horns; and from the nature of our aliments themselves. Nor is there any kind of glue that could more powerfully join the parts of animals together; as we experience in fish-glue, and that of joiners or cabinet-makers, &c. See §. 15. ult.

R E M A R K.

Add that this oil is disposed to unite with the water by attrition from a considerable portion of an ammoniacal or neutral salt joined with a good deal of unelastic air; which salt we obtain in an alkaline volatile state by distillation.

§. 6. Earthy particles then (§. 3.) cohering longitudinally, and tied together by an intervening cohesive glue, (§. 5.) compose first one of the least or most simple fibres; such as we have a knowledge of rather from reason than sense.

R E M A R K.

The finest microscopes have been hitherto insufficient to lead us to a sight of the smallest moving and nervous fibrils, and still less can we ever expect from them to get any sensible idea of the mechanism by which sensation and motion are effected. For how motion is modulated to produce animal sense, or how animal sense and will can produce motion, we can only conjecture, and never certainly know. We proceed, therefore, to compound visible fibres.

§. 7. But the least fibres which appear last to the sight, if you will take up with their first appearance and the established opinion, are of two kinds.

R E M A R K.

From the figure of these two kinds of fibres, as we shall presently see (§. 8, 9.) we may distinguish the former by the title of filamentary, and the latter of membranous.

§. 8. The

§. 8. The first kind of these fibres (§. 7.) is lineal, namely, such a form as makes their length considerably large in proportion to their breadth; and which, by disposing of the elementary particles in a right line, must of course lay them generally parallel with the neighbouring or contiguous fibres. Examples of such fibres we see in the bones, and most easily in those of a foetus; and likewise in the tendons, ligaments and muscles: only we must here always remember, that the eye never reaches to the smallest fibres, but to larger ones made up the smallest, and like to them in slenderness, placed together in a rectilineal course. That these are not different from the smallest fibres, we are persuaded by the most accurate microscopes of Mufse and Lewenhoeck; by which, the muscular fibres divided even to the last, appear similar to the larger, till, at length, they seem mere lines, like spiders threads.

§. 9. The second kind of fibres (§. 7.) are those which are conjoined with a breadth frequently larger than their length, in forming what is commonly called the *cellular* tunic or membrane; tho' the name tunic or membrane is on many accounts improperly given to it.

R E M A R K.

From what has been said, we may admire nature no less for her wise œconomy than simplicity, in thus forming all that variety of parts we see in an animal from one simple mass of clay or slimy matter,

matter, compounded of earth and glue; from whence the body is not only augmented from a single point in the ovum to its full growth and stature; but, like the timbers of a ship, is also every day repaired during life, 'till, at length, not two jots of the old or first materials remain. This renovation of parts is made slower in some constitutions, and in some organs, than in others. How quickly the animal humours with the hair, nails, &c. are renewed every one knows: and we may venture to say, that once in three years the change is universal; at the end of which time, tho' a man remains the same identical person, he is not the same matter.— But we proceed from these simple fibres to the next least compounded solid which they compose, viz. the *tela vel substantia cellulosa spongoides*, the cellular web-like substance.

§. 10. The said cellular substance is made up partly of the forementioned simple fibrills (§. 8, 9.) and partly by an infinite number of little plates or scales, which, joined in various directions intercept small cells and web-like spaces; and by extending round every, even the least moving solid parts of the body, conjoins them altogether in such a manner as not only sustains, but allows them a free and ample motion at the same time. But in different parts of the body we observe a great variety of this web-like substance, in respect of the proportion betwixt the membranous sides and intercepted cells, as well as the breadth and strength of those sides, and the nature of their contained liquor, which is
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sometimes more watry, and sometimes more oily.

R E M A R K.

The extension of this substance, not only with the skin round the whole body, but also round every viscus or organ, and round every individual moving fibre or vessel of them, into the cavities of the bones, and even the substance of the brain and its medulla, is a modern and wonderful discovery of anatomists, by which we have great light into many otherwise obscure diseases. This substance in its ultimate or finest state being composed of simple membranes, when compacted and convoluted, gives birth to the least or most simple vessels, which, again reflected through plates of the same substance compacted together, make compound and vascular membranes, to the consideration of which we next proceed.

§, 11. Out of this net-like cellular substance compacted by a concretion of the membranous plates or partitions, and pressed together by the force of the incumbent muscles and distending fluids, arise other broad and flat plates or skins in various parts of the body, which being generally disposed in one and the same direction, seem to have yet a better right to the title of membrane, than the former; and these being convoluted into cones and cylinders, pervaded by a flux of some juice or liquors brought to them, put on the name of *vessels*, or else being extended round some space that is in a plane parallel

parallel to itself, we call it a *tunic* or coat. But that tunics or coats are formed out of the cellular substance is proved to ocular inspection, especially in the aorta or dura-mater, by maceration; and the coats of the muscles are thus evidently of a cellular fabric, while they resemble the texture of other membranes; from a degeneration of the pericardium as a true membrane into the cellular substance, or membranes of the great blood vessels belonging to the heart; from the origin of the hard and thick membranes which are about encysted tumors, and which are formed only in the cellular substance; lastly, from the easy change of the dartos coat of the testicle, and the nervous tunic of the intestines, by inflation, into the cellular fabric.

§. 12. All the vessels with which we see tunics commonly painted, are an addition to the cellular net-work, and in no wise constitute the nature of a membrane, but are superadded to the membrane itself, which is first formed of the cellular net-like substance. Betwixt the mashes or spaces of the intestinal net-work of vessels, perfectly well filled by the Ruyschian art of injection, we still see that the white cellular substance which remains, greatly exceeds the bulk of the vessels, although, by their preternatural distention, they take up more room by filling more of the space. But for membranes compounded of fibres, interwove or decussating

ting each other, I know of none such, unless you will take ligamentary or tendinous fibres for them, which yet are spread only over the face of some true membrane.

§. 13. This cellular web-like substance in the human body is found throughout the whole; namely, wherever any vessel or moving muscular fibre can be traced, and this, without the least exception, that I know of, in any part whatever. See remark of §. 10. and of §. 17. following,

§. 14. The other elementary substance of the human body (§. 2.) viz. *concrementum glutinosum chondroides*, which cannot be truly called either a fibrous or cellular plate, is a mere glue extravasated and concreted, not within the fibres, but in spaces betwixt them. In the bones this extravasated substance is manifest enough; for you see the fibres very distinct in the bones of a foetus, in the intervals betwixt which you perceive the vessels running; so that every bone in the skull on all sides resembles the teeth of a comb. But this fabric is so altered in an adult person, that a cartilaginous juice being extravasated in the spaces betwixt the fibres, we see small plates formed of it.

§. 15. But here the course of nature seems to be such, that even the filamentary fibres (§. 3.) are all first formed of such a transfused glue. And that the membranous or scaly fibres of the cellular substance (§. 7.) are thus formed appears, from those cellular fibres

produced in the thorax from a concreted vapour or serum transfused through the surface of inflamed lungs, which are thereby conjoined to the pleura; for these perfectly resemble the true and natural cellular substance. The same appears also from a comparison of the foetus with an adult; for the large subcutaneous cellular substance has in a foetus a mere jelly in its stead interposed betwixt the skin and muscles, which last we observe very firm in a foetus. This theory is again illustrated (1.) *synthetically*, by the fibrous cake one may draw out from blood by stirring it round with a probe; and from the membrane, which may be in like manner formed thence according to the experiment of Ruysch, and Albinus's membrane from mucus; lastly, from the formation of a polypus, silk and glue. (2.) *Analytically*, we see, from diseases, that the bony fibres are formed first of a compacted glue; because the hardest bones, by a dissolution of their glue, return again into cartilage, flesh, and jelly: such experiments we make on the bones of fish and other animals with Papin's digester.

§. 16. The *anthropogenesis*, therefore, or formation of the human solids, seems begun when a gelatinous water, like the white of an egg, with a small portion of fine cretaceous earth, runs together into a thread, from some pressure, the causes of which are not our present concern. Such a filament, by the mutual attraction of cohesion, intercepting

ing spaces betwixt itself and others, helps to form a part of the cellular net-like substance, after having acquired some toughness from the neighbouring earthy particles, which remain after an expulsion of the redundant aqueous glue. And in this net-like substance, wherever a greater pressure is imposed on its scales or sides, they turn into fibres and membranes or tunics; and in the bones, lastly, they concrete with an unorganised glue. (§. 14). Hence, in general, all parts of the body, from the softest to the hardest, seem to differ no otherwise than as the former have more of the earthy particles more closely compacted together, with less of the aqueous glue; while in the softest parts there is less earth, and more glue. See the remark of §. 3.



LECTURE II.

Of the cellular substance and its fat.

§. 17. **W**E have now seen (§. 10.) that the cellular web-like substance is made up of fibres and plates, which are neither hollow nor vascular, but solid; although they are afterwards painted by an accession of vessels. But the principal differences of its fabric are the following. In some parts of the body it is open and loose, being formed of long and distant plates; in others, it is thin and compact, being made up of short fibres, concreted together. I find it thinnest and of the shortest fibres, betwixt the sclerotica and choroides of the eye; and betwixt the arachnoides and pia mater of the brain. I also find it very thin, but more tender and conspicuous, betwixt every two coats of the intestines, stomach, bladder and ureters: 'tis also thin and empty under the skin of the penis, forehead, and in the lungs, in which last we call it vesicles. 'Tis composed of yet longer fibres, where it is extended over the larger vessels, under the name of a capsule or vagina; as through the viscera, and particularly the liver and lungs. Its principal use is to bind together the contiguous membranes, vessels and fibres in such a manner as to allow them a due or limited motion. But the cellular substance, so far

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as we have hitherto described it, hardly ever admits of any fat into the cells; which are rather moistened by a watry vapour, that is somewhat gelatinous and oily, exhaled out of the arteries and received again into the veins. The truth of this is easily demonstrable from injections of oil and water, either alone or with fish-glue, made in all parts of the body. When this vapour is, by inflammation, too glutinous, or, from any cause, absent or abolished, the small fibres grow one to another, and the contiguous membranes or plates are cemented into one, with a loss of their motion.

§. 18. The cellular substance and its plates or scales, are still more loose and open where it divides the muscles and all their fibres (even to the ultimate fibre); and likewise where it surrounds and sustains the least vessels with their free motion. That within the cavities of the bones is also made up of bony plates, with membranous ones intermixed; and lastly, it is the most loose and open of all, round the surface of the body on all sides, betwixt the muscles and the skin.

§. 19. Into the empty spaces of this cellular substance, (§. 18.) almost every where, in the foetus is poured at first a jelly, and afterwards a fat; which at first is grumous or curdy, but afterwards clear and leafy; namely, a thick, insipid, inflammable liquor, which, in a cold air, congeals, in some degree, into a solid, especially about the kidneys

neys of herbivorous and horned cattle ; but is softer and yellower in carnivorous ones ; and while they are living, it seems a mere fluid, or very nearly so.

§. 20. Through this cellular web-like substance the small vessels are spread and ramified in all parts of the body, from whose arterial extremities the fat is deposited into the cells, and afterwards absorbed by the venal orifices. This passage, from the arteries into the adipose cells, is so free and short, that there must needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, water, dissolved fish-glue or jelly, and oil not excepted, which is always very sluggish in passing through the vessels, even of living animals. The oily fat, in this substance, is separated and expelled from the artery, not by any long ducts, but by transfusing on all sides through the whole extent of the vessel ; inasmuch that when an artery is filled or injected with water, there is no part of the surrounding cellular substance, but what swells with the moisture. How quickly it is collected from the arteries, appears from the speedy renovation of it, by a returning fatness after acute diseases. See §. 25.

§. 21. But this return of the fat absorbed by the veins, we are taught from the sudden effects which labour or exercise of the muscles more especially has in consuming the oil of very fat animals ; also from the
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consumption of our fat in fevers, and from the cure of dropfies, where the water transfused into the cellular substance, is in a manner absorbed and thrown out by the intestinal tube; and lastly, from the transuding of water and oil from the venal orifices, when injected by the syringe. Whether any of the nerves pour out their contents into, or are spread upon, the adipose cells, is an improbable question. But 'tis certain they in most parts run through this substance, and hereby divide, in their course, into the minutest filaments, so small that you can no longer trace them by the knife. But then the fat is both insensible and unirritable.

§. 22. With regard to the sponge-like communications of this substance, 'tis remarkable, the intervals or spaces betwixt the plates or scales that make up their sides in the cellular membrane, are every where open, and agree in forming one continuous cavity throughout the whole body. This appears from the inflation which butchers make by a wound of the skin, and which being once received into this substance, is easily driven so as to raise the skin all over the body; and likewise from an emphysema, in which the air received by a wound of the skin, being retained, causes a swelling throughout the whole surface of the body; and finally from diseases, in which a watry or serous humour is deposited into all the cells of this net-like substance, throughout the body. That none

of the cellular fabric is excepted from this communication, appears from wounds or accidents, wherein even the vitreous body itself of the eye has received the flatus of an emphysema; and again from disease, in which the gelatinous serum of a dropsy has been found transfused even into the cavernous bodies of the penis.

§. 23. The great importance and use of this cellular substance, in the animal fabric, must be evident to all who consider that from this part alone proceeds the due and healthy firmness, strength and stability not only of all the arteries, nerves and muscular moving fibres of the body, but likewise of all the fleshy parts and viscera, which are made up of the former, folded together within this substance: and even the figures, cavities, pliability or flexures and motions of the soft parts depend entirely on the cellular membrane, in some places of a lax and in others of a more close and hard fabric. That out of this substance joined with vessels, nerves, muscular and tendinous fibres (a great part of all which are before formed of this substance only) all the viscera, all the muscles and glands, with their ligaments and capsules, are entirely composed; and that only from the different length, tension, quantity or proportion of this the diversity of our glands and viscera arises; and lastly, that this alone makes up by far the greatest part of the whole body, as we are certain, although the whole

whole be not formed out of cellular filaments of this kind.

§. 24. The *uses* of the fat are various ; as to facilitate the motions of the muscles in all parts, lessen their attrition against each other, and prevent a stiffness or rigidity ; it fills up the intermediate spaces betwixt the muscles in such a manner, with the cavities about many of the viscera, that it readily yields to their motions, and yet supports them when at rest ; it serves as a stratum or bed to conduct and defend the vessels in their course to all parts ; it gives an uniform extension to the skin, and serving as a cushion to ease the weight of the body in many parts, at the same time it renders the whole of a comely, agreeable shape : it probably by returning and mixing with many of the humours, abates their acrimony ; it has a principal share in forming the matter of the bile, and by transuding through the cartilaginous incrustations of the bones, it mixes with the articular liniment or synovia ; also by exhaling in a living person from the mesentery, mesocolon, omentum and round the kidneys, it lubricates the surfaces of the viscera with an oily emolient vapour, and by interposing betwixt their integuments, prevents their growing one to another.

§. 25. The fat is deposited into the cells of this substance by much sleep, with rest of body and mind ; whence being collected in too great a quantity, it proves injurious by compressing

the veins, and by causing too great a resistance to the heart it makes a person short-breathed and liable to an apoplexy or a dropsy. The same humour is repelled from the cells into the veins, and being rapidly moved along the arteries, the excessive motion will not allow it to go off laterally by the secreting pores to the cells: whether this celerity of the blood be, by violent exercise, watchings, cares of the mind, a salivation or a fever. Thus it causes an increase of acute diseases, tinges the urine of an high colour, and forms a great part of its hypostasis or sediment. After a sudden consumption of it, 'tis soon renewed again from good juices, or healthy humours: but in a languid valetudinary habit, a gelatinous serum, instead of fat, is deposited into the cells; and this causes the dropsy we call anasarca, affecting the whole habit, together with an external hydrocele or watry swelling.

R E M A R K.

Hitherto we have surveyed the œconomy of nature in her wise formation of the most simple solid machinulæ of our body, namely such parts as by their form and elasticity are capable of a reciprocal action, so as to perpetuate for a number of years the motion that is once given them. These we see she has formed of the most permanent earthy particles incrufted with an oily glue; which as they are prepared by a continued unequal attrition of fluids through a numerous series of vessels, must receive a spherical figure*, that will be apt to change by compressure, at

* These are the common physical or natural elements of all animals and vegetables, easily commutable one into the other.

least on their surface, which consists of a soft yielding glue. Such particles then having the same power of mutual tendency or attraction, will each of them apart be spherical; but when two or more of them meet in contact, their surfaces must yield in proportion to the density and vicinity of their central contents, and from round, become depressed spheroids or cakes, whence both their contacts and cohesion will increase, yet so as to allow a free motion of the central parts to slide one by the other so long as the quantity and tenacity of the surrounding glue answers to the moving distractile force applied. A number of such parts then united longitudinally will form a simple, elastic and distractile fibril; or six of them conjoined together, at equal distances, will form a simple, elastic and least globule: and those we see make the primary and most simple instruments of motion in an animal body, to the state or disposition of which all the other solid or fluid parts they compose correspond in the strength and action. Here the solids, as the main spring, have the predominant ruling force over their elastic contained fluids, which, as the regulating or weaker spring must answer in their nature and motion to the former; whence the diversity of native constitutions.—If the central points of these earthy stamina, in a fibre or globule, come close enough to cause a due cohesion of parts, which may sufficiently yield to and return the given impulse required, 'tis said to be healthy and *robust*. If their cohesion be too close, and connecting glue too tough or dry, they are said to be *rigid* and unactive; but if they recede farther, have a glue too watry, and cohere less than suffices to receive and return the due vibrations,

vibrations, they are then said to be weak and *lax*. And these two last are the morbid conditions which call for the care of the physician. What has been said of these primary simple machinulæ is true in a greater degree of the more compound membranes, vessels and viscera which they compose; and also of the lymphatic, serous and red spherules, with respect to their constituent parts, and to each other.

Hence we see, (1) that *life* is the mere motion, and *health* a certain latitude or degree of that motion, betwixt the elastic solids and fluids, extended through a series of vascular parts gradually more compounded. (2.) That an excess or defect in this motion alters the texture towards death or disease. (3.) That moderate exercise repeated makes the parts strong and healthy, by keeping them moveable upon each other, by expelling the redundant watry parts, and giving the whole glue a due firmness and cohesion. (4.) That one of the least vessels closed into a fibre must be stronger than that vessel was before? from the increased contact and cohesion. (5.) That a callosus is tougher and less distractile than original flesh? because it is less vascular and without the interposition of cellular substance; whence also it will be little or nothing perspirable. (6.) That the strength, rigidity or laxity of the fluids and solids are correspondent one to the other; i. e. lax solids will make lax thin fluids, whence a weaker reaction of them in the vessels, &c. which will pave the way to slow, cold diseases; as the contrary will dispose to acute inflammatory diseases. (7.) That astringents are such as approximate the solid stamina and thicken their connecting glue; whence they stop evacuations
by

by thickening the humours and lessening the diameters of the vessels: so that given sparingly in laxity of the solids and fluids they corroborate; but in excess, and in old, laborious rigid subjects, with an inflammatory lentor, (or even in a cold visciditv, unless joined with stimulants) they coagulate the juices and suppress the actions of the solids. (8.) That oils relax without weakening, because they have a greater tenacity than water; which last dissolves the connecting glue and weakens the automatic action or elasticity of the stamina and fibres thence arising. For which reason large and sudden evacuations leaving the solids loose and unactive upon the fluids, cause faintings and weakness. (9.) We see that where there is a natural laxity of the blood and its vessels, as in women and children; where they move with a greater impetus than suits their cohesion, as in fevers and periodical hæmorrhages; or where the connecting glue is too much dissolved by a putrid alkaline contagion, as often in eruptive and epidemical fevers, there may be an extravasation (according to the degree or multitude of those causes) either of ferous or sanguineous fluids into the cellular substance of the skin, and other larger internal cavities, without a rupture of vessels, in which manner flow the courses of women. Hence by a dissolution of the connecting glue, from a venereal or scorbutic acrimony, the bones, vessels and the elastic globules break easily; whence frequent hæmorrhages with livid cutaneous spots, &c. And thus hæmorrhages happen oftenest in the nose and lungs, because the arteries have their coats there thinner, and in the lungs have little resistance or confinement from the empty cells, and very thin epithelium or internal cuticle: whence

whence an infection is sooner sent to the blood through these parts, and consumptive ulcerations here oftener take place. (10.) We see that from the birth, the strength and cohesion of the solids gradually increase with age, while the fluids continue less altered, till at length a senile weakness and natural death ensue from the dead resistance of the rigid membranes and vessels not yielding to the now weaker nervous influx; the nervous secretion daily lessening and the cortex indurating as the vessels close by age. (11.) We see how an injudicious internal use of astringents powerfully contracting the larger vessels, may rather increase than stop an hæmorrhage, and some local fluxes; or by causing too great a push upon the smaller vessels in a weakened part, may produce one *de novo*. (12.) We see that in the warmer countries and seasons of the year, where there is always a greater tenacity of the fluids and a weaker spring or action of the solids, bleeding is oftener called for to relieve the tone of the vessels in full habits; and this especially in wine countries, as south of France, Spain and Italy; for that from its globular matter and moderate increase of the circulation breeds blood very fast. (13.) We see why in most fevers, and in colder countries or seasons, 'tis necessary for the patient to have a moderately warm room, warm bed, warm drinks, sleep, &c. by which the tension of the vessels is relaxed, and tenacity of the humours lessened; from both which a fever is augmented. (14.) We see how a thick moist air in foul weather, seems heavy to us, though it be much lighter than a dry serene air? because from its less pressure on the body the spring of the solids upon our fluids is weakened. (15.) Why onions, mustard, pepper and other
alkaline

alkaline stimulants are used to promote the digestion of putrescent meats, pork, salt-fish, &c. ? because they are antiseptic and by increasing the muscular strength of the stomach make them stay there not too long. (16.) Why a dropical patient so easily relapses after freeing him from his waters ? because being lodged where the fibres have the least tone and elasticity, as in the lymphatics and cellular substance, where corroborants seldom penetrate, 'tis very difficult to restore or confirm their first strength. (17.) What pains are increased and what lessened by blood-letting ? namely it relieves in full habits with a pleuritic or sily blood, but where rheumatic or hysterical pains come from too great a laxity of the smaller vessels and a loose watry sluggish blood, Gum. Guaic. Cinnab. Cort. Peruv. Rad. Valer. Rhei & Camph. are preferable to the lancet, as that increases the generating cause. (18.) Why inflammatory tumours are painful and resisting, but œdematous ones indolent and pitting ? because the lymphatics and cellular substance, the usual seat of the last, have but little elasticity and sensibility. §. 21. (19.) Why inflammation and pain are always less by bleeding ; and how it may provoke perspiration, sweat or urine ? viz. by abating the compressure of the excretory ducts, by lessening the force and distention of the blood vessels, and by relaxing the blood and humours themselves urging upon the distressed part. (20.) Why the pulse of a fat person compared with that of a lean one is weak and languid to the touch ? namely because the ictus is lost in a soft, unresisting and unelastic substance, and receives little or no increase or return from the well clothed contiguous bone. (21.) That sudorifics, diuretics and scarifications are much preferable

preferable to tapping or strong purging in drop-sies; because by exhausting the parts gradually they better contract and recover their lost tone, while the better elastic or globular parts of the juices are still retained in the habit. (22.) That there are no proper or peculiar adipose vessels and receptacles, only such as are also common as well to the watry and gelatinous as by a greater laxity or impulse to the serous and even red parts of the blood from whence the fat laterally recedes. Lastly, as the cellular fabric surrounds every individual tubulus or nervous fibril, both in the encephalon, in its progress thence, and in its ultimate expansion (23); we see thence how a weakening of this fabric, by excess of dram-drinking, tea-drinking and lewdness, has reduced the old athletic British constitution of our ancestors to the modern puny tenacity of habit, obnoxious daily to a train of nervous and other disorders, almost unknown to our progenitors. And why these have worse effects on the young, witty, studious and sedentary; who have a natural tenderness of the cellular fabric and nervous system; to relieve which, the cortex was timely and happily discovered.

LECTURE III.

Of the arteries and veins.

§. 26. **T**HE compound membranes made out of the preceding more simple parts, we shall hereafter better describe each in their respective places. Of these membranes there are several common to the arteries; which are elastic tubes or canals, forming parts of longly extended cones, whose diameters decrease as they divide into more numerous branches. But where the arteries run for some length, without sending of branches, as towards their ultimate extremities, their convergency is not very evident; and at length, where they are called capillaries, and wherever they give passage to only a single red globule, they are either cylindrical or very nearly so, from the imperceptible diminution; but their transverse sections are every where and without exception circular, when the artery is full. The common basis of the cone in all arteries is either in one or the other ventricle of the heart; and the apex of the cone terminates either in the beginning of the veins, or in the beginning of the cylindrical or anastomosing part of the artery. In some places indeed the arteries seem to diverge or dilate; at least they become there of a larger diameter after they have been filled or distended with wax; which possibly

possibly may arise from some stoppage of the wax, by whose impulse that part of the length of the artery becomes more distended than the rest. Examples of this kind we have in the vertebral artery, at the basis of the skull, in the splenic artery, in the flexure of the carotid artery, according to Mr. Cowper's injections; and lastly, unless all my experiments deceive me, in the spermatic arteries.

§. 27. There is indeed *no external adventitious coat* perpetual and proper to all the arteries; but the office of such a coat is supplied to some of them by one single external and incumbent integument, which in the thorax is the pleura, and in the abdomen the peritonæum. In the neck a sort of thicker cellular-substance surrounds the arteries; for the membrane of the pericardium which on all sides closes round the aorta, soon disappears by changing into the cellular substance. The dura mater imparts a capsule that surrounds the carotid artery as it passes out thro' the hole in the skull for that purpose. But the first true external membrane common to the arterial tube in all parts of the body, is the cellular substance (§. 17.) which in some parts, (as in the thorax) we often see replenished with fat. (§. 19.)

§. 28. This *cellular coat* is in its external surface of a *more lax*, open texture, painted with a great many small arteries and veins; and it has nerves running through its substance, which are none of the smallest.

There is sometimes so much of this cellular substance about the artery as might occasion one to think it hardly belonged to it as an external coat or lamella, but rather as some foreign net-work added to this vessel. Thus we find it in the arteries of the neck, groins and subclavians; in the mesenteric, cœliac and hepatic arteries. And these are the vaginæ or capsules of the arteries, formerly observed by some eminent anatomists.

§. 29. As this *cellular coat* advances more inward, and nearer to the light and capacity of the artery, it becomes *more dense* or solid, and is tied more closely together by small fibres, insomuch that there appears to be no tendinous coat of the arteries distinct from this last part of the cellular substance; as is evident from maceration, whereby the inner stratum of this arterious tunic changes into a cellular fabric.

§. 30. Within the former, and nearer the light or capacity of the artery, it has a *coat of muscular fibres*, which are in general imperfect circles; that is to say, no fibre any where makes a compleat circle round the vessel, but a number of segments conjoined together, with their extremities turned off sideways, seem to form one ring round the artery. These fibres, in the larger arterial trunks, form many strata or plates one within the other, appear of a redish colour and are remarkably firm and solid; but in the smaller arteries they are by degrees more difficult

difficult to demonstrate. Within this there seems to be a sort of continuation from the former cellular membrane from betwixt the muscular fibres, although it be among them invifible, and here very difficult to demonstrate ; into the cells of which a chalky concreting matter is poured when an artery ossifies.

§. 31. The *innermost coat* of the artery is thin or cuticular, and finely polished by the influent blood ; so as to form a fingle incrustation that every where lines the fleshy fibres, (§. 30.) which being somewhat loose, or not very continuous one to the other ; this innermost lining prevents the blood from infinuating into the spaces betwixt them. 'Tis every where smooth and without valves, altho' from a sort of mechanical necessity it sometimes, at the origination of branches, forms a projecting eminence ; as we see at the branches produced by the arch of the aorta. Yet in arteries of the viscera the innermost coat is softer and more lax than what we have described ; and 'tis there in a manner wrinkled and almost friable.

§. 32. The arteries themselves *have arteries* which are more particularly spread thro' their external cellular coat ; and springing on all sides from the next adjacent small arterial trunks, form numerous, branchy net-works, which are all of them indeed very minute, but plainly appear, even in the fœtus without injection, to be very numerous. We see
also

also there are *nerves* which descend for a long way together through the surface of the artery, and, at last, vanish in the cellular substance of the vessel ; of which we have a specimen in the ex and internal carotids, and arch of the aorta. And from these, as in other muscles, the arteries seem to derive a muscular and convulsive force*, very different from that of their simple elasticity. Does not this force shew itself plainly enough in fevers, faintings and passions of the mind ? But the artery, abstracted from its nerves, is in a manner insensible and unirritable.

R E M A R K.

* This is a successive contraction of the arterial fibres, like those of the intestines, from the larger to the less diameter, or the reverse ; by the first, the blood moves quicker in a certain trunk to the veins, as in blushing, anger, &c. by the last, it reverts back to the heart in faintings, hysterical fits, &c. Hence come the pains, improperly called flatulent, which are local cramps of the artery, beyond which you will scarce feel any pulse, but before it a strong one ; whence, in hysteric, and other nervous cases, you have often a pulse in one wrist and little or none in the other. When violent in the carotids, it often kills by an apoplexy, that is now a-days very frequent, and in which bleeding avails little. Seizing the heart itself, it often kills suddenly, without leaving any apparent cause, upon dissection. (V. Willisii Cap. 8. de apoplexiâ obs. ult. in Theologo). By this peristaltic motion
D of

of the arteries, the passions quicken, retard or suppress the renal, uterine, hepatic, lactiferous, salival, and other secretions; being a great key to many otherwise unintelligible symptoms, &c. See §. 44 and 553.

§. 33. The *sections* or divisions of arteries show themselves with a round, light or hollow capacity, because they are elastic; and this is the reason why, from small arteries, as those of the teeth, hæmorrhages are sometimes fatal. The aorta, indeed, of the thorax and abdomen, the carotids of the neck, and some other arteries of the dead body, from their lessened extension, appear somewhat flat or depressed; but their round figure or circular section is every where restored by injection. *Their elasticity* is also evident in that powerful compressure, which a segment of a large artery makes upon the finger that distends it. In the living body, indeed, this force yields to that of the heart, but instantly recovers itself, when the heart is relaxed, and restores the artery to its former diameter; and this makes the pulse, whose full explanation ought to be preceded by an history of the heart: at present, it may suffice for us to say, that all the arteries have this pulsation, although the systole and diastole thereof can be perceived by the finger, only in the larger ones, and not in the smaller ones naturally; but by an increased motion of the blood even the lesser ones make a violent pulsation, as we see in an inflammation.

§. 34. The

§. 34. The *strength* of the arteries is considerable enough, but as the dense, hard network of the outer cellular coat (§. 29.) refuses to yield to a distending force, it breaks without much difficulty, almost easier than the coats of the veins; and from thence aneurisms often arise. But in general, the trunks are, in all parts of the body, weaker, and the branches stronger in their coats; whence the impulse of the blood may exert a considerable effect upon the former, but least of all on those of the limbs. From hence it is, that aneurisms are most frequently formed near the heart; for in the lower extremities, the strength of the arteries, and of the veins too, is much increased.

§. 35. With regard to the *course and general distribution* of the arteries, nature has every where disposed of them in places of the utmost safety, because wounds cannot happen to the smaller of them without danger, nor to the larger without loss of life. The skin is spread with numerous short and small arterial trunks, but the larger ones, defended by the skin, creep along betwixt the muscles and the bones well guarded.

§. 36. In the *particular division or ramification* of an arterial trunk, each branch sends out smaller circles by a numerous subdivision; the last extremities of which, you will scarce be able to trace. Here the lights or sections of any two branches taken together, always exceed the light of the trunk

from whence they come, in nearly a sesquialteral proportion, or as one and a half to one, or somewhat less. Also every trunk, just above its bifurkation or division, is somewhat broader or more expanded. The angles, at which the branches go out from their trunks, are generally acute, either half right angles or nearly so; to the forming of which angles, as we see in mechanics, there is required the longest projection. Instances of their going off at right angles, or nearly so, we have in the lumbal or intercostal arteries; of their going off in a retrograde or reflected course, we have one instance in the coronaries of the heart, and another instance in the spinal arteries, which are produced by the vertebrals. But generally speaking, those, which are esteemed retrograde or reflexed, were sent off, at their origin, in acute angles; such as the ascending artery of the pharynx, the descending one of the palate, the umbilical and mammary arteries. Lastly, we often observe larger arteries arising under lesser angles, and smaller arteries under greater angles: but it is rarely, that we observe two arteries of a larger diameter run together into one trunk of a less; as in the basilaris, formed out of the vertebral arteries. §. 338. [In many parts the arteries have repeated alternate undulations or flexures, as they run on in a spiral course, wherein we see their diameter often considerably enlarge; as in the colon, rectum, womb, face, spleen, &c. This

This, and the division into branches larger than the trunk, greatly abates the velocity of the blood ; as does the largeness of the angle with the trunk, and the number of undulations by which an artery, that lies in a small compass, may be easily extended to a great length, as in the uterus, &c.]

§. 37. The arteries are frequently conjoined one to another by intermediate or *anastomosing branches*, in such a manner, that the twig of some certain artery shall run to meet one of the same kind from another neighbouring artery, and by joining together with that form one trunk. Instances of this kind we have many, among the large trunks in the intestines ; among the middling ones, in the kidneys, womb, &c. and among the smaller, in all parts of the body ; inasmuch that there is no one part of the human body, wherein the neighbouring arterial trunks, whether of the same, or of different denominations, do not form anastomoses or joinings one to the other, by intermediate, lateral branches. Of such rings diverging laterally from the arteries, and returning again into themselves, we have instances betwixt the iris and choroides of the eye. The extremities of the arteries, which are either cylindrical or nearly so, send off smaller branches, which, for their extent, are more numerous, and generally disposed like a net, so that each branch, by smaller circles, forms anastomoses with those of its

neighbouring branches. And thus we find it in all membranes.

§. 38. Lastly, one of the least arteries is either changed by a continuation of its canal into a vein, in such a manner, that the ultimate little artery, which is generally reflected, having surpassed the angle of its reflection, becomes now a small incipient vein; or else, a branch, sent out at right angles from the artery, is inserted under a like angle into the branch of a small vein. Both these kinds of mechanical fabrication of the smaller arteries with the veins are demonstrated to us by the microscope. And these vascules we see sometimes large enough to receive only one, and sometimes several blood-globules at a time. See §. 6. In the viscera, we find the small arteries disposed not so much in net-works, as in a different fabrication, wherein the small branches descend very thick or in clusters, parallel to the trunk, so as to resemble brush-pencils, a variety of little trees or bushes, small serpents, threads, &c. according to the variety of the parts, whose composition they enter.

§. 39. Other arteries again pass not into veins, but into *excretory ducts*, like unto veins, which convey a humour different from that of the blood. This continuation of the arteries and ducts is somewhat more difficult to discover than the former, (§. 38.) and is generally not so easily described or traced by

the injection or liquor that is urged into them.

§. 40. Another termination of the arteries is, *by branching out into pellucid ones*, of much less orders, which we sometimes observe to be not only continuous, but true and direct trunks of the sanguineous arteries; as in the ophthalmic artery of the eye, if you trace its branches into the choroides, then into the arterial circle of the uvea, and lastly, into the colourless arteries of the iris, vitreous body, and crystalline lens: so likewise, in the red branches of the same ophthalmic artery forming a net-work in the conjunctiva tunica, to which is continued the pellucid, but arterial net-work of the albuginea or sclerotica: the truth of this appears from inflammations, from the redness of parts caused by warm vapours, from cupping, from artificial emptying and repletion of the arteries, and lastly, to the eye itself by the microscope of Lieberkuhn, commonly called solar, applied to the membranes of frogs, by which we see the colourless globules pass out of a red artery, and go off into pellucid continuous ones. The uriniferous ducts or tubes of the kidney are thus continuous with the sanguine arteries. In this structure of the arterial extremities, we see it is no difficult matter to urge any red liquor or coloured injection into the smaller pellucid vessels.

§. 41. As for the small, lateral, excretory ducts, we before mentioned, (§. 39.) which seem to go off as branches from the smallest red arteries, and again laterally detach other trunks; they make a greater resistance, than the former, to an injection; whence it becomes more difficult to fill their excretory vessels. And this seems to be the fabric in most of the small glands and viscera, destined for secretions; where, with some difficulty, we can urge a liquor from the arteries into their excretory ducts.

§. 42. Another termination of the arterial extremities, is, *into the exhaling vessels*; and this is a manner of their ending, very frequently to be observed in all parts of the body. The whole external and internal skin, all membranes of the human body, which form any close cavity, all the ventricles of the brain, the anterior and posterior chambers of the eyes, all the adipose cells and pulmonary vesicles, the whole cavity of the nostrils, phauces, stomach and intestinal tube, through which the air has a passage, are all of them replenished with exhaling arteries of this kind. These breathe out a thin, watry vapour or humour, very little gelatinous, which being condensed or collected together by standing, sometimes makes no inconsiderable quantity; and particularly, by disease or death, they yield a watry, but congealable lymph, hardening by heat or alcohol. The truth of this is
easily

easily demonstrable, from the watry sweat that ensues after injecting the arteries with that liquor warm. In some places, indeed, they exhale not a thin vapour, but blood itself, as we see in the cellular fabric of the penis, urethra, clitoris, and nipple of the female breast; in all which, the blood itself is naturally poured out. Does not every secretion, that is made in true glands or hollow cryptæ, bear some analogy to this exhaling fabric?

R E M A R K.

Even the whole encephalon and nervous system are a kind of cylindric, exhaling vessels, whose contents are, in part, elastic globules, and move the slowest of any juice; in some nerves, by tubular attraction and arterial impulse, only modulated by impulsions of objects one way, and (in some) of the mind the other way: this juice, moving in the organ immediately by continuity, moves the mind, as the mind again thereby moves the organ, not by any flux, but by a transfered motion; as when 10,000 ivory balls fill a tube, if you put in one more it will instantly thrust out another at the opposite end.

§. 43. Whether or no, in all parts of the human body, the pellucid vessels, (§. 40.) arising from the sanguine ones, and carrying a humour thinner than blood, again send out other smaller vessels to be subdivided into still lesser orders? We seem, indeed, not to want examples of this, in the manner proposed

posed to us by the celebrated Boerhaave and other professors. That the aqueous humour is separated by very fine vessels, generated from the colourless arteries of the iris, is, indeed, more than probable. That the red coloured vessels, in the cortical substance of the encephalon, separate a juice, pervading the medullary substance, by the intermediation of other smaller vessels, we are almost certain. And the like we are persuaded from an erysipelas, or yellow inflammation, arising from the yellow or serous globules, impacted into smaller vessels.

§. 44. It may be then asked, if there are not yellow arterious vessels of a second order, which send off lymphatic ones of a third order, from whence, by degrees, still lesser kinds of vessels branch out? such a fabric does not seem agreeable to the very easy transition that is made by the blood, mercury or wax into the exhaling and perspiratory vessels; into the uriniferous tubuli, with the adipose and pulmonary cells; nor is it very difficult for the blood to stray into the lactiferous, lymphatic and lachrymal ducts, whither it should seem not able to penetrate, if it went through any other intermediate vascular system, smaller than the blood-globules, which make the same journey. Nor can this system be allowed by the great impediment or retardation that must arise to the humours in a third, and
much

much more in a fourth, and lesser orders of vessels.

R E M A R K.

From what has been said, we see the arteries act by a double force on their contents; the one, a dead automatic elasticity, (32.) the other, a vital or muscular constriction from the nerves in their fabric. (33.) The first continues to operate in the dead animal, the latter only in the living; and that variously, as to force and celerity in different organs, or in one and the same organ at different times, in proportion as their nervous fabric is more or less irritated by distention or acrimony internally, or from pain, passions or nervous consent externally. This is the force that gives a due form and modulation to many of the secreted juices, and carries them through ducts and vessels, which, after death, are no longer pervious; and, although the great share which it has in almost all febrile or inflammatory, nervous and painful diseases, seems little regarded by our British physicians; yet, some of the greatest note, and particularly among the Germans, have built their systems almost entirely hereupon: thus, sometimes Hippocrates calls it nature, Helmont calls it his archeus, Hoffman and Sthall their convulsive spasms; so prolific of diseases.—These are the forces which actuate all medicines so as to produce their various effects, which are always in proportion to the state of these powers and that of the confined juices on which they act; and, therefore, never exactly the same in two people, or at two different times.—These powers, however, in some measure, antagonize one the other; for the greater the arterial density, the less their nervous

vous irritability and the reverse. The former, too much increased, paves the way to all acute, inflammatory and painful diseases; as the latter does to all slow, nervous and hysterical complaints. This last is the door-keeper to the catamenia, whose generating or material cause is a plethora, but the motive or actual cause a fever, with a topical or painful irritation of this sluice-keeper in the womb, without whose permission, a plethora can never issue there. This is the milk-maker in the breasts, to which the chyle affords matter to be moulded: milk and chyle being very distinct humours, &c. we see the nervous system influences this muscular power of the arterial; and that again acts upon the nervous, both as to the secretions and distributions. All pleasing passions and sensations, as well as painful, uneasy ones, variously intend or remit the circulation, by acting on this muscular fabric and force of the heart and arteries. All medicines in themselves are dead tools, which exert effects varying according to the strength or disposition of this agent, viz. the elastic and muscular force of the artery, in conjunction with the density or laxity of the humours, and more or less sensibility of the nerves. A spasm of this muscular force of the artery in any emunctory, causes a suppression, as in the skin, kidneys, lungs, womb, &c. to be relieved by warm bathing, vapours, semicupium, opiates, nervous and hysterical medicines, after one spare bleeding. Any slow stimulus acting on this nervous and muscular force of the arteries, causes a nervous atrophe, whether from pain, want of mucus, putrid or scorbutic acrimony, &c. In a word, this is a principal key towards understanding the nature and cure of numerous

merous symptoms of diseases, and the various operations of medicines. See §. 552 and 553.

Of the veins.

§. 45. The *veins*, in many particulars, (§. 36.) resemble the arteries. Their basis is in the ventricles of the heart, and their apices in the extremity of each branch, thro' all parts of the body, excepting one instance in the liver. And, in a great number of parts, they run parallel with the arteries, one by the side of the other. But the veins differ from the arteries in various respects, as we shall now see.

§. 46. The membranous fabric of the veins is thin, every where smooth, and very difficultly separable into distinct coats or membranes, in which there are but few places, wherein one can demonstrate muscular fibres. Notwithstanding this thinness of their sides, the veins are, in most parts, very firm, and do not easily burst with inflated air; being, in most instances, stronger than the arteries, if experiments do not deceive us. But they burst much more easily in living, than in dead animals, as appears from morbid instances in the arm, face, leg, thigh, &c. Nor do they support themselves like cylinders after being divided, but they collapse together, so as to make their light or capacity appear like a slit; except they are sustained and hindered from collapsing thus, by some stronger cellular substance

stance placed round them, as we see in the liver and womb. [They are like the arteries, but slightly irritable, unless the stimulus be of the chemical or more acrid classes; for, in that case, they contract themselves with a convulsive force, greater in proportion than that of the arteries themselves.] (§. 32.) They have no pulsation, unless the venal channel is somewhere obstructed; or when, in dying people, the blood is thrown back again from the right auricle into the descending and ascending cava.

§. 47. The veins are much larger than their corresponding arteries, having the square of their diameter often double or triple that of the latter, and, in some places, almost quadruple; as near the emulgents, and in the venal trunks. They differ, likewise, from the arteries in their course or division; having more numerous trunks and branches: for to one artery in the limbs, we usually meet with two veins. The larger veins are also branched in a more net-like disposition, by forming more frequent anastomoses one with another; for not only the smaller branches, but even the larger trunks of the veins are conjoined one to the other within its neighbourhood, upper with lower, and right with left, by apparent inlets or inosculation. They affect more than arteries to run near the surface of the body; and through the limbs, neck, head, &c. they run a long way covered with little more than

than the bare skin ; which is a circumstance we very rarely observe in arteries : and for the same reason, they often go out in their course, to a considerable distance from the arteries. For, in this case, the veins follow the surface of the parts next the skin, without their corresponding artery, which, in the mean time, descends to a considerable depth, attended, in its course, by some smaller venal branch. In the smaller branches of the vessels, where they make not-like dispositions in the membranes, and compose the internal fabric of the viscera, the veins and arteries commonly run contiguous one with the other ; but here the veins have generally a less serpentine or inflected course.

§. 48. The veins have their origin, as we said before, (§. 37.) from the terminations of the arteries. They sometimes arise by a continuation from the inserted branches, or from a reflexion of recurved trunks, of the smallest arteries. Others again are either continued from veins less than those which carry blood, or else receive additions and roots from them ; as we see, for instance, in the lymphatic veins of the thoracic duct. Other veins, of a bibulous kind, arise from absorbing ducts or orifices opening through out the whole extended surface of the body ; as in the chambers of the eyes, the cavities of the intestines, bladder, womb, breast, peritonæum, pericardium, and ventricles of the brain. For from these issue a watry sweat,
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by injecting the venal trunks with that kind of liquor, which easily resembles an ordinary sweat throughout the whole human body: hence, we meet with injections of water, fish-glue or oil distilling from the vena portarum into the cavity of the intestines; of which experiments, we shall speak more largely hereafter in a proper place.

§. 49. Not much differing from the former, are those veins which, arising in all parts of the cellular membrane, or rather sponge-like substance, return thin vapours, dropfical waters, and dissolved fat again into the mass of blood; or which take up again and return the blood itself from the cellular fabric of the penis, clitoris, or nipples of the breasts after the venereal act. And that inhaling veins of this kind open into all the glands, is highly probable; where, by absorbing the thinner humour, they leave the remaining mass of a thicker consistence; of which we have instances in the bile, sperm, mucus, &c.

§. 50. That there are pellucid veins of a smaller class, but resembling those which convey blood, appears from the same experiments, which demonstrate the pellucid arteries (§. 40.): thus in the iris of the eye, there are small veins, and in the adnata tunica of that organ, more than a few trunks, which, in a healthy person, are naturally pellucid. The larger of these veins, which come next

to those that carry blood, are much more conspicuous than the arteries of the same kind; and are usually called *lymphatic vessels*; of which we shall speak more at large, when we come to describe the *lacteal vessels*.

§. 51. Namely, in most parts of the human body [but in brute animals they are more easily and clearly discovered] are found transparent veins, often full of a reddish, yellowish, and almost pellucid liquor, hardening like the white of an egg with a boiling heat or alcohol; which veins being formed of very thin coats, [have, like the blood-veins, (§. 46.) a proportionable degree of irritability, from any chemical or very acrid stimulus; whence we infer them to be muscular or nervous, notwithstanding they are pellucid, like the fibres of fish, frogs, &c.] have frequent valves or partitions, which make them in those places seem jointed, or knotted like a reed, when they are turgid; these, by degrees, meeting together, either all or most part of them, empty their contents into the thoracic duct. But all the lymphatics, in their course, meet together in a peculiar kind of conglobate glands, into which they enter, and from the shape of veins becoming arterial or like converging cones, they divide into small branches, and then proceed to meet together again in other little trunks. They are found seated on all the surfaces of the viscera, in the thorax and abdomen; but are more easily and clearly

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discovered in brutes : they run thro' the lower part of the face, muscles of the tongue, the adjacent parts of the neck, and those parts of the upper limbs, which are nearest the trunk, as far as the bending of the elbow ; throughout the whole length of the mediastinum, before and behind, and wherever we find conglobate glandules, either in the neck or thorax : the lymphatic veins are also spread through the whole lumbal region that is contiguous to the aorta, the mesocolon and pelvis, vessels and surface of the testicle ; and in the lower limbs wherever they are supplied with conglobate glandules. Whether they extend further into other parts, throughout the whole body, or through the brain, eyes, hands, feet, back, fore part of the peritonæum, &c. remain, as yet, undetermined ; at least, there are not examples enough in the human body, upon which one can depend to evince the truth of their existence. But they are every where to be found upon the surfaces of the viscera, and about the larger blood vessels.

§. 5 . The *valves* of these pellucid vessels are composed of two semilunar, or rather semicircular, projecting membranes, which give way to the fluid that goes towards the larger trunks ; so that, by applying themselves close to the sides of the vessel, they leave a free light or capacity thro' it. But the same valves, if the contained liquor is pressed back towards the smaller branches

branches of the vessel, being filled out therewith, swell or expand, so as to shut up the light of the canal.

§. 53. But many valves of the same kind are also found in great numbers *within the larger blood-veins*. These, joined with the side of the proceeding vein, intercept a space, of which the outerside is the vein itself, and the inner the valve, which, by its convexity, stands out within the bore or light of the vein; so that the parabolic space or hollow mouth of the valves always look towards the heart: they are found in all the subcutaneous veins of the limbs, in those of the neck, face, tongue, and in the veins of the penis: at the origin of the larger branches there are two, three, four, and sometimes five of them together, while in their smaller branches they are only single. There are none of these valves in the deep running veins of the viscera; and, therefore, none in those of the brain, lungs, heart or liver, or through the whole system of the vena portarum, nor in the kidneys or womb (except one or two valves in the spermatic vein); nor, lastly, are there any in those smaller blood-veins, which are of a less diameter than the twelfth part of an inch. Whether there are any such valves in the vena azygos is questioned; but I have not been able to find any. [Valves have been sometimes, though very rarely, found in the vena azygos: and at the mouths of the hepatic and

renal veins : there I have several times observed a sort of wrinkles in the place of valves.

§. 54. In the smaller venal branches there are a set of long, sharp-pointed or parabolical valves of a more extended figure, as the vein is smaller : and these make a greater resistance than the larger valves, to hinder the blood from returning back upon the parts.

§. 55. The common use or office of these valves is, to determine the pressure that is given from any quarter upon the veins, towards the heart, by allowing no opportunity to the venal blood, that has once entered the trunk, which they intercept, to flow back to the branches. For since the coving spaces of the valves open upwards towards the heart, the blood enters into, and expands them. Thus those parts of the valves, which stand out with a free motion within the light of the vein, approach each other towards the axis, until the opposite sides, by meeting together, shut up the tube. This we know from inflations, ligatures and injections of the veins ; for you never can force a liquor easily into the veins, by urging it against, or contrary to, their valves. They do not, indeed, every where shut up the whole cavity of the veins ; but where they shut not close, they always intercept the greatest part of the light.

§. 56. Another office of the valves in the veins, seems to be for sustaining the weight
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of the blood, that its upper columns may not gravitate upon the lower; nor the blood, flowing through the trunks, make too great a resistance against that which follows it through the branches. For if, from the slower return of the blood into the veins, its weight or pressure shall, in any part, much exceed the impulse, that drives it on, so as to cause some part of the column to descend by its weight; 'tis, in that case, immediately caught and sustained in its relapse by the next adjacent valve, which hinders it from urging against the next succeeding column, and affords time and opportunity for some contiguous muscle, by its pressure or concussion, to send forward the said column. And this is the reason, why valves are placed in veins of the limbs and neck; in which parts, they are both more numerous and more robust than elsewhere. And this is the cause, from whence varices or herniæ are formed in the veins, when the blood, entering the hollow valves, urges their solid convexity downwards, and makes the vein dilate in that part.

LECTURE IV.

Of the circulation or motion of the blood through the arteries and veins.

§. 57. **T**HE arteries and veins, which we have hitherto described, contain either blood or lymph. The red blood, whose nature we shall explain when we come to treat of secretion, fills the arteries and veins by all seen, or commonly known, which we call those of the first or larger order, and which have their origin in the heart. These the blood so fills in a living person, that, at some times, they are very loosely and imperfectly distended by it, and, at other times, they are rendered very full and turgid. After death, the veins are found fuller of blood than the arteries; but sometimes, when the person has been dead a considerable time, the small veins have been found distended with air. But the arteries of a dead body commonly contain only a small quantity of blood.

§. 58. This distending blood then, in a living person, is rapidly moved through all the said vessels. The truth of which is demonstrated to us from wounds, by which the patient soon expires, from the loss of so much blood, as was necessary to distend and move the vessels for the maintenance of life;

life ; which loss of blood happens almost instantly from the larger arteries, and sometimes very suddenly from the smaller ones : (see §. 60.) but from the veins, unless they are some of the largest, this loss of blood is more slow and difficult ; yet, are there not wanting instances of fatal hæmorrhages from wounds of the veins, not large as in the inner corners of the eyes, under the tongue, &c. In short, the experiments made upon living animals, sufficiently evidence the impulse and rapidity with which the blood is moved, particularly through the arteries ; where, in the larger trunks, it runs most swiftly, at the rate of 149 to 74 feet in a second ; but, in the least of them, it runs above twenty times slower. And, in the larger veins, where it moves so much faster than in the smaller, the blood's celerity is less than in the arterial trunks, in the same proportion, as the lights or sections of the arteries are less than those of the veins, i. e. twice or almost thrice slower. Another argument of the circulation, is the compressure and relaxation of a vein, whereby the blood is promoted from one valve to another.

§. 59. This motion of the blood is in the veins uniform or equable enough ; but, in the arteries, it is alternately greater when that vessel is more dilated, and less when it is contracted. [This is proved by ocular inspection in living animals.]

§. 60. That the motion the blood describes, is a course through the sanguineous arteries into the veins, is discovered from experience. For 1st. it is certain, that all the arteries and veins communicate or open one into the other; because often, from one, and that a small artery, all the blood shall run even until death, not only out of the wounded limb, but from the whole body. Of such fatal examples, we have a number from an inner artery of the nose, from the gums, a finger, tooth, cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the skin, and even the bite of a leach. There are, therefore, of course open ways by which the blood speedily flows from the venal, into the arterial system, and the reverse.

§. 61. That the blood again in the arteries flows from the heart towards the extreme parts of the body, is proved by a ligature in the living animal. For whatever artery shall be stopped by a ligature, a swelling ensues in that part betwixt the heart and the ligature, whilst the other part is emptied beyond the ligature, which is the part of the artery more remote from the heart; neither has it there any pulsation, nor if it be there wounded, will it yield any blood. The same effects which we see follow from a ligature, are likewise often produced by disease; as when some tumor, by compressure, or some aneurism intercepts the motion from
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the heart. Instances of this kind we have seen in most of the considerable arteries.

§. 62. But for the course or motion of the venal blood, it has been always more doubted of; almost all the ancients have been persuaded, that the blood in the veins flowed through them, either from the heart, or from the liver, to all parts of the body. Very few of them have known, that this was an error. Several of them have, indeed, acknowledged it to be false in the pulmonary vein: (§. 107. ult.) as Servetus, Columbus, Valverdus, Johannes Langius, Lambergius, Pigafetta, Arantius, H. Conringius Mercatus, Platerus, Spigelius and C. Hoffmannus, from whom we must not except Galen himself. But that the blood did not move from the heart in the vena cava was known to still fewer anatomists of the ancients; perhaps, only to Andreas, Cæsalpinus, and from an extraordinary accident to Vesalius, and doubtfully to H. Dietericus.

§. 63. Dr. William Harvey is the first who experimentally asserted the motion of the blood, returning in the veins to the heart, in such a manner as to render the whole intelligible, and leave no room to doubt of it. And first, *the valves of the veins* (as he observes) lead us to this truth; for all of them readily transmit wind, wax, or other injections to pass from the extreme or remote part towards the heart; but they obstinately resist giving any passage to the
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said wax or flatus, to pass back from the heart towards the extreme parts, unless you burst or break through them. The same course, which we see the veins give to wax, mercury or oil injected, must of consequence be the same which, by their action, they give to the blood; since the colour of the reflux liquid will not make any change in its direction.

§. 64. Moreover, the valves, placed in the right ventricle *of the heart*, have such a fabric, as we shall hereafter see, that they freely permit blood, flatus or wax to pass from the venal trunks of the cava into the heart, but deny any passage from the heart again into the veins.

§. 65 Again *ligatures*, in a living person, may make the thing more evident. When the veins of the limbs are tied, either by design or accident, with the limb itself about the hams, arms, ancles or wrists, the limb below the ligature swells, the veins fill and distend themselves, so that one may easily open them, and they make a free discharge of blood: but, at the same time, nothing of this kind happens above the ligature, nor are any of the veins to be seen there but less conspicuously. The same phenomenon happens when the veins are compressed by swelled and schirrhous glandules in the viscera; and from polypus's the veins are often largely swelled, or enlarged into tumours.

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§. 66. The experiments to prove this course of the blood, which have been made in living animals, are still more accurate. From them it appears, that, by tying any vein, in a living animal, near the cava, or belonging to the pulmonary veins, that part always swells, which is most remote from the heart, all below the ligature appearing distended with the retained blood, while above and next the heart they are pale and flaccid. From this principle it is, that the ancients are used to apply ligatures to the limbs in profuse hæmorrhages, to keep back some part of the blood, sufficient to support life, from returning to the heart, which would drive it into the wounded arteries. Lastly, if the arteries are tied at the same time with the veins, these last remain flaccid and empty, but, upon removing the ligature from the arteries, the veins are immediately filled.

§. 67. Another proof we have in the *transfusions* of blood, in which all the vital gore from the arteries of one animal is urged into the veins of another exhausted of blood, whereby the heart, arteries, and empty veins of the latter become so turgid, and well replenished, that they work the whole machine of the animal with a remarkable degree of vivacity, or even cause it to labour by a plethora. In like manner, medicinal *liquors*, *injected* into the veins, have exerted their operations respectively; proving anodyne, or inebria-

inebriating in the brain, emetic in the stomach, purging in the intestines, or coagulating the blood through the whole body; which is a plain argument they pass with their virtues first to the heart, and from thence sent through the arteries to the organs, which they affect.

§. 68. But that the blood passes from the least arteries into the least veins, we are clearly taught by *anatomical injection*; where, by one arterial trunk, we easily fill all the arteries and veins, almost throughout the whole body; provided the liquor be watry or very fluxile, so as to pass easily in the vessels of the head, mesentery, heart and lungs.

§. 69. Lastly, *the microscope* has put the matter beyond all doubt in the pellucid tails, feet, mesenteries and membranous parts of animals, where we see, that the blood, brought to the extreme parts by the arteries, is poured either into small veins, continuous with the reflexed artery, or else goes through branches of the arterial trunk into the parallel communicating vein, by which it goes on to the parts nearest the heart. This is the way in which the blood passes as well into the least veins, which are capable of receiving only one globule, as into those that are somewhat larger, being able to admit two or more globules to advance forward in a breast. But that there is no spongy or parenchymous interposition betwixt the arteries and veins, in the general course of the circulation,

circulation, is proved both from microscopes and injections. [For if there were any such parenchyma or spongy mass betwixt the arteries and veins, the hardening injections would show it, by appearing extravasated in a like unshapen mass.]

§. 70. The Harveian circulation is, therefore, now received as a medical truth by every one; namely, that all the blood of the human body is carried through the aorta from the left cavity of the heart to the extreme parts or converging ends of the arterial branches; from whence the whole mass is again transmitted into the least veins, which convey it to the larger, and from them into the cava and heart itself; in which course, it perpetually goes and returns during life.

§. 71. Yet there are some instances where, by passions of the mind, a sudden revulsion by copious blood-letting, or a vascular convulsion, the blood has been forced to recede back from the smaller into the larger arteries. And on the other side, where an obstruction being formed above the valves, the blood has been known to slide back from the venal trunks into their smaller branches. But then these accidents are very momentaneous or sudden, and the blood soon returns into its natural course.

§. 72. The course of the humours in the *lymphatic veins*, which have valves, appears both from the nature of those veins and from ligatures; for every lymphatic vein tied,
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swells betwixt the smaller extremities of it and the thoracic duct; but grows flaccid betwixt the said duct and the ligature. All the valves in these, like those of the blood-veins, give a free passage for the contents to flow to the thoracic duct: for thus they admit flatus and mercury; but they make a resistance, and often an obstinate one, to any return the other way.

§. 73. *The vapours*, that moisten the whole cellular substance, the steams of the abdomen and other venters, are all thus drunk up by the least pellucid veins, and so conveyed along to the blood-veins, that their contained juices may pass on to the heart; and from thence it is, that an œdema ensues when a vein is compressed by ligature; because, by intercepting the course of the absorbing veins by the ligature, the vapours stagnate unabsorbed. In the other smaller vessels, we can make no experiments, but they appear conformable to what we have said, both by reason and analogy; and are likewise supported by the experiments of water or other liquors, absorbed out of the cavity of the intestines, thorax and pulmonary vesicles.

§. 74. All juices, therefore, in the human body are drove out of the heart into the aorta to the extreme parts, from whence they are all returned again to the heart by the least veins; those humours only excepted, which are exhaled or discharged without

without fide the cavities of the body. But to compleat this circle, it remains for us to find out a course for the blood, from the right to the left cavities of the heart: but then this pre-supposes and requires us to be first acquainted with the history of the heart, and the pulmonary vessels.



LECTURE V.

Of the heart.

§. 75. **T**HE fabric of the *thorax* is a craticle of moveable bones and cartilages, which, in general, resembles a truncated cone, as we shall hereafter (§. 278.) declare more at large. The lateral parts of this cone are two membranous bags, terminated above by an obtuse end at the first rib, where they lie very near together, and are distinguished only by the interposed cellular substance. The obliquity of the plane, dividing these two bags, is such, that the right is much the broadest, and adheres in its descent all along to the whole middle of the sternum; while the left bag descends, not from the sternum, but from the cartilaginous ends of the ribs. The inner central sides of these bags, opposed one against the other, makes up, what anatomists have called, the *mediastinum*. [But in ascending the mediastinum, is remarkably inclined towards the left of the sternum.] These bags have no where any communication one with the other; so that the right may be opened or pierced, and the lungs therein may be consumed, without injuring the left. But the simple dense membrane, which forms these bags, outwardly invested with the cellular substance, is called the *pleura*,

pleura, being harder than the *peritonæum*, especially where it adheres to the back; but is somewhat softer in its fore part. The capacity of the *mediastinum*, or that interval which lies betwixt the right and left bag above, contains the *thymus*, and some conglobate glandules, fat, and vessels. [This capacity of the *mediastinum* is much broader above, yet not inconsiderable below.]

§. 76. Below the same bags growing broader depart one from the other, and leave a capacity through the whole middle part of their extent, by which the said bags are divided one from the other. And this capacity is that of the *pericardium* (§. 77.) following. But the bags of the *pleura* on each side the *pericardium*, descending both before and behind it, terminate finally on the *diaphragm* on which their base is cut off obliquely, with a descent from before backward; so that each cavity is before shorter upwards, as behind they descend longer and lower. Within these bags, then, play the dilatable lungs. The back part, likewise, of these bags lying near to each other, are yet separated by the cellular substance, which terminates in the *pericardium*, and includes the *aorta*, together with the *œsophagus* or *gula*: and this we call the *posterior mediastinum*.

§. 77. The *pericardium*, or third bag, which first the cellular substance, and then the conjoined *pleura*, loosely cover on all sides,

as an outer coat, does not, indeed, extend to the sternum, since the lungs, when distended, cover the heart before, and interpose betwixt the sternum and pericardium in their lower part, and the mediastinum, gradually departing towards the left side, forms altogether a narrow interval under the lower end of the thymus, close to which the lungs meet on each side; but, this vital situation you will alter or corrupt, unless you are very careful in your manner of opening the thorax. The pericardium has a broad, but somewhat rounding basis, which, in younger subjects, adheres more laxly to the diaphragm; but, in adults, it grows thereto very firmly, by the cellular substance spreading broader to the right, and narrower towards the left. It is somewhat larger than the heart, which, therefore, may move freely therein. [This membranous capsule, or fence of the heart, was never known to be absent.]

§. 78. Upwards the pericardium grows gradually smaller or narrower, ending above the heart in an obtuse conical appendix, extended over the coats of the large blood-vessels by strict cohesion, almost to the upper edge of the sternum; that is to say, the pericardium, having reached the eight large trunks of the blood-vessels, which come out from the heart, adheres to them in such a manner, as to form cylindrical productions, embracing each vessel on all sides; whence
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it appears like a kind of septum or partition, betwixt every two neighbouring vessels. But this capsule, surrounding the vessel like a sheath, keeps its own ligamentary texture (§. 80.) but for a small length; soon degenerating either into the cellular fabric, which, in the lungs, like a capsule, surrounds and extends itself along with all the large arteries and veins, or else it finally changes into the external membrane that covers the lungs.

§. 79. The *arteries* of the pericardium are either from those of the thymus, which accompany the upper and lower phrenic nerves, or from the larger phrenic arteries, from the branches of the mammaries and mediastinals, the bronchial, œsophageal and posterior mediastinal arteries. The *venal trunks* of the pericardium have a like origination, but appear with most evident anastomoses or openings from those of the right into the others of the left side. The *nerves* of the pericardium are from the superficial branches of the cardiacs, (§. 94.).

§. 80. That which makes the proper substance of the pericardium, is a strong, white, compact membrane, more robust than the aorta itself, composed, at least, of two plates, [these plates are, from the density of the cellular substance, inseparable by art; but the distinction of them appears plainly enough in larger animals, and from the interposed vessels] betwixt which, the nerves of the heart, and some small vessels, descend; but,

by the help of the anatomical tube, (whereby a membrane, to be divided, is tied or stretched over the bottom, and pressed by a perpendicular column of water) it separates into a great number of plates. Its outer surface, being spread with the cellular substance, gives it there a somewhat rough appearance, while internally it appears smooth or highly polished, and moistened on all sides by a watry vapour. This vapour, which we have, times without number, observed in the living animal, composes some, though naturally a very small quantity, of a water within the pericardium; which is often a little reddish, and subviscid or gelatinous, and, by disease, is sometimes increased to an immense quantity; yet the existence of such a water here, is injudiciously denied by some. The *water* of the pericardium is of a lymphatic nature, because, by the heat of fire, it hardens into a jelly; and from hence small fibres and a cellular substance (§. 16.) are often formed, joining the heart to its pericardium, in inflammatory diseases of these parts. This liquor is separated without any intermediate glandules [or any visible pores] from the small exhaling arteries of the heart, auricles and pericardium; as may be proved by a similar transfusion of water or fish-glue, injected into the large arteries.

§. 81. The *Use* of the pericardium is, to contain the heart, and to support and strengthen

strengthen it as a fulcrum or prop, that, in contraction, the fibres of the heart may be drawn together without distorting the large blood-vessels, and that it may less fluctuate like a pendulum every way, by altering the position of the body. For these reasons, we find it in all animals that have a true heart. A watry vapour here bedews the heart, hotter and quicker moved than other parts, so as to hinder attrition and cohesion betwixt it and the pericardium; but when this vapour is dried up or deficient, the pericardium adheres either to the whole surface, or to some one part only of the heart.

§. 82. The veins, which carry back the blood from the whole body to the heart, if we except those of the lungs, (which are transmissory ones) are reducible to two, viz. the cava and the porta. The *cava* is improperly named in the singular by anatomists; since it is no where one single trunk, but partitioned obliquely into superior and inferior. The lower of the two large veins, which is the biggest of them in man, ascends immediately above the diaphragm from the right side, towards which it is a little convex or gibbous to its union with the upper cava, and together with that in its back part, forms a middle partition betwixt the right and left sinus: but the left side of the venal tube degenerates into the right auricle, whose fibres are a continuation from those of the cava.

What we have here said of the lower cava is also true of the upper.

§. 83. Thus, by the meeting of the upper and lower cava, a sinus or cavity is formed with a convexity to the right, and inwardly filled with strong, fleshy fibres, detached betwixt the two simple membranes, and variously interwove. But the same cavity to the left and forepart, dilates forwards into an almost perpendicularly oblong or oval form, and terminates above with a blind pointed end, which is free from adhesion with the heart, and lies incumbent on the great artery. This cavity also, like the former, has plenty of fleshy fibres placed betwixt two very thin membranes, almost in a parallel position, and these form a kind of arch extended from the right to the left edge of the whole cavity, and round the anterior half cylinder of this cavity; and these muscular arches are connected together by some of the least fibres. This anterior and stringy part of the cavity is called the *auricle*; but that to the right and posterior part is called the *sinus*.

§. 84. Where the lower cava opens into the right auricle, from the tumid column of the left side of the foramen ovale, arises a moon-like membrane, naturally compleat in its figure, and from its thinness sometimes net-like; and this being extended round the lower edge of the auricle, grows thinner all the

the way as it is incurvated to the right, but does not quite surround half of the auricular circumference, the cavity of which it serves like a partition to divide from the vena cava. This is, by anatomists, called *Eustachius's valve*. The oval foramen, we shall describe hereafter, (§. 840.).

§. 85. The blood of the upper and lower cava, meeting together in this *atrium*, or porch of the heart, (§. 83.) composed of the sinus and auricle, there waits for the relaxation of its ventricle, into which it is propelled by a constriction of the muscular threads of the auricle, by drawing the anterior semicylindrical part of the auricle into a plane; while, at the same time, they bring the middle arch backward, to the anterior and posterior edge of the beginning of the heart. Thus the blood of both cavæ, being mixed together in the beginning of the heart now disincumbered, is drove through the edges of the open valve, in such a manner, as to urge the tricuspid valves of the right ventricle close to the sides of the heart. But the blood is now hindered from returning again into the lower cava, both by the contraction of the auricle, the resistance of the succeeding blood from the abdomen, and of the *Eustachian valve*; and upwards it is hindered from ascending both by the motion and weight of the consequent blood.

§. 86. The figure of the heart itself, in some measure, resembles half a cone, if

the cone be split into two longitudinally in the direction of its axis. 'Tis almost triangular, only the end of it is obtuse, and the lower side of it is flattened, in proportion to the diaphragm on which it lies incumbent, and is thereby sustained. But, in expiration, the *situation of the heart*, with its apex to the left nipple, is such, that the convex surface of the cone is so inclined within the pericardium, under the great blood-vessels, as suffices to place its thicker semicircular curvature, which modern anatomists call its *obtuse margin*, directed to the upper and to the left side of the breast; in its lower and anterior part, the heart is also extenuated into a kind of edge, which is called its *acute margin*. This is the general situation of it in mankind; but in brutes the heart, being almost parallel to the larger axis of the thorax, its apex or tips only extend to touch the diaphragm.

§. 87. The whole heart is hollow, having its right or *anterior ventricle*, communicating into the right auricle and sinus, of a more broad and semicircular figure, and not so long as the posterior left ventricle; and it terminates in the shorter tip of the bifurcated apex of the heart. The mouth of this ventricle, where it opens into the auricle, is elliptical, and terminated by a white glutinous margin, more callous than tendinous; over this, plates of muscular fibres are spread, and some fat lies outwardly upon these.

§. 88. From

§. 88. From the said callous margin is extended within the heart, a membranous ring, formed by a reduplication of the internal membrane of the auricle, extended so as to float within the ventricle, to which it was before continuous. But this same ring, in that part which fluctuates in the ventricle, is so split or divided into three unequal triangular portions, that you may, in some measure, give them the name of valves, and count three of them in number, although they are, in fact, only continued parts from one broader ring. These were, by the ancients, named *trigloebines* or *tricuspid* valves.

§. 89. That part of these valves, which lies next to the sides of the heart, is strengthened by tendinous fibres, which, meeting together in their course, are inserted by very strong cords, partly into the sides of the heart, and partly into papillary or cylindric muscles, which arise upward from the left side of the right ventricle towards its right side. The largest of these muscular columns is that which answers to the biggest of the valves; which is both the uppermost, and that which answers to the adjacent mouth of the pulmonary artery. The least of them is the lowest, and seated to the right side.

§. 90. The usefulness of this valve is evident enough; for the right auricle being contracted, by a constriction of the fibres in the partition betwixt the two auricles, the
blood

blood contained in the right porch of the heart (§. 85.) being impelled from the circumference towards the axis, like a wedge, separates the pendulous portions of the ring, called tricuspid valves, and presses them to the sides of the heart. Thus is filled the right ventricle of the heart, while the largest or uppermost of the said valves shuts the pulmonary artery, lest the blood, by the weak impulse of the auricle, should flow into that artery; the blood thus received and confined within the right ventricle of the heart, is, by the strong contraction thereof, more powerfully expelled into the artery.

§. 91. The sensible flesh of the heart, being irritated by the quantity and weight of this warm blood, is thereby solicited to a contraction: for that the heart, being irritated, will contract itself in a person dying, or even lately dead, is proved by injections of water, and inflations of air, whereby the heart, then quiescent, is recalled to its motion.

§. 92. The heart's motion is performed by *muscular fibres*, the originations of which, in general, are, from rings formed of the cellular substance, compacted into a callous ligament, agreeable to the description given in §. 87. and with which, all the larger blood-vessels, at their opening into the heart, are surrounded. From thence the fibres, which arise, descend gradually in an oblique winding course towards the left side, and forward

forward to the apex, in many distinct plates, and sometimes a little traversing each other, the innermost of them being the most transverse. In the flat side of the heart (§. 86.) there are few fibres, and so thin, that when you have removed the fat, the cavity of the right ventricle appears almost uncovered. That which is called the left ventricle, is, however, very firmly invested by the fibres; which, after surrounding the same ventricle, form a slight decussation in the septum cordis with the fibres of the right ventricle, and are interwove with them. Some of these fibres descend into the cavities of the ventricles, and form there the fleshy columns mentioned at §. 89. Others, at the tip of the heart, are wound in a vortical or whirling position, the two horns ending by a strong fasciculus or bunch in each ventricle. A very thin and smooth membrane covers the external and internal surface of these fibres; but the external membrane, especially where 'tis spread over the coronary vessels, contains much fat beneath it. I have, for my own part, not been able to distinguish any thing more particular in the muscular fabric of the heart, with any tolerable degree of evidence; because it is the peculiar property of the fibres in the heart, to join together in branchy appendices or heaps, in so strict union, that they cannot be separated without laceration.

§. 93. But there are several eminent anatomists, whose ingenuity and communicative freedom I respect, who have represented and described those fibres displayed and separated. Namely, the external fibres of the heart, common to both ventricles, descending to the tip, and, then taking another course, to insert themselves into the septum; others again, at the tip, to perforate the left ventricle, and return, in a contrary course, to the basis, along the inner surface of the said ventricle. But the middle fibres, betwixt the aforesaid inner and outermost ones, being variously inclined towards the basis, they form the septum. Which descriptions, as they are not much different from my own observations, I shall make no opposition to, although I have never been able to see this disposition of them sufficiently manifest, and am acquainted with great anatomists, who have not herein been more happy than myself. [And others have given us figures and descriptions of still different orders of fibres, of which the outermost run counter to the innermost, while the intermediate are transverse.]

§. 94. These fibres of the heart, like other muscles, are furnished with *nerves* of their own, very numerous and of various origin. The first and uppermost are on the left side from the ganglion of the intercostal with the uppermost cervical nerve, from the trunk of the intercostal nerve itself, and from

from its middle ganglion; on the right side, they come almost entirely from the middle ganglion, and not from the uppermost, but, in part, from the pharyngæal branch of the eighth pair. These nerves descend into the heart, partly on each side the aorta, betwixt that vessel and the pericardium, and are distributed all over the surface; and, partly, having first made various small plexusses, they descend betwixt the windpipe and the great arteries, which come out from the heart; and, here, the right and left cardiac nerves, make one or more plexusses, joining their sides from one to the other; but sometimes they remain distinct from each other. From this same plexus, or plexusses, other nervous twigs pass betwixt the aorta and pulmonary artery to the coronary artery of the heart; others cross the pulmonary artery, and go betwixt it and the left auricle to the coronary artery of the same side; and others, finally, descend behind the pulmonary artery to the left sinus and flat surface of the heart. To the cardiac plexus, above described, other large nerves accede from the fifth and lower cervicals, and sometimes from the phrenic nerve, and from a ganglion of the lowest cervical with the intercostal, to which join large roots from the lowest cervical nerves. The last described nerves, which are larger, softer, and more transversely disposed, mix themselves with the foregoing plexus. Lastly, there are some small branches, uncertain

as to course and number, which join the cardiac plexus from the recurrent and eighth pair of nerves, and making various inosculation with the intercostals, are confounded or lost among those of the eighth pair. As for those nerves, which some eminent anatomists have seen ascending from the great abdominal plexus to the heart, through the foramen of the vena cava, I have never been able to find such; although it is easy enough to discover the diaphragmatics in that place, having ganglions peculiar to themselves, of which those anatomists make no mention.

§. 95. That these nerves conduce powerfully to move the heart, is evident from the common nature of muscles, and from the increase which follows in the heart's motion, by irritating the eighth pair of nerves, either at the brain, or the spinal medulla; and from the languors that ensue upon tying those nerves, which proves fatal, either suddenly or within a few days, even though you happen to make the ligature on but a few of the nerves that come to the heart; for the intercostal, and especially those from the ganglion of the upper thoracic, cannot be tied.

§. 96. But that there are still other causes, besides that of the nerves, conducing to the motion of the heart, we are persuaded from the permanent motion it exerts, while moist in dissected animals, which have it of a like make with man, as in the dog, in which we have observed it for many hours; and in animals,

having only one ventricle, the motion lasts much longer, even after the heart is cut out from all the nerves that supply it with any influx. However these causes may be, all our experiments agree in this, that the quiescent heart, irritated by heat, cold, vapours, poisons, and especially the force of impelled flatus, watry liquors, wax or blood, immediately contracts itself, by putting all its fibres into a rapid motion, with a considerable strength, which terminates in an entire evacuation of the heart, [by a force sometimes common throughout the whole heart, and sometimes affecting only a particular part of it.]

§. 97. 'Tis, therefore, evident, that the heart, stimulated by the impulse of the venal blood, without other assistance, contracts itself. And that this contraction is convulsive, made with great celerity, and a manifest corrugation of the fibres; whereby the whole heart becomes shorter, [therefore, those learned gentlemen must have been led into a mistake, who assert, that the heart becomes elongated in its contraction] thicker and harder, so that the apex or tip advances towards the basis; which, in living brutes dissected, I have often, with the greatest evidence, observed. But the heart does not appear to turn pale in this action, in such animals as have a warm blood; although the muscular sides of the heart, at the same time, swell inwardly, and make a compression

sure on the blood, like that which we feel upon the finger, when thrust into the contracting heart. But that the heart is considerably enough emptied in this action, appears from the internal surface being full of eminences, which exactly answer to opposite cavities, and to the thick reticular arms or columns interrupted by sinusses. Finally, the apex of the heart, being contracted a little like a hook, strikes against that part of the pericardium next the thorax. (§. 86.) [Forwards, there is also a pulsation from the left venal sinus, which is, at that time, particularly filled. In expiration, the heart strikes violently more upwards and forwards. The truth of both these we know by experience, from the touch.]

§. 98. The blood, which is pressed by the contracted heart, endeavours to escape in all directions; but being drove from the muscular sides, towards the axis of the ventricle, by the reaction of what is lodged betwixt the venal ring (§. 88.) and sides of the heart, the looser ends of the said ring are driven forwards, and extended inward at the same time. By this action, upon the whole circumference of the ring, it not only becomes extended itself, but, at the same time, throws back a part of that blood into the right auricle, which had before descended into the cone of the open valve, whose sides, now approaching, shut up the venal orifice, more closely as the heart contracts more strongly, by whose force

force the tricuspid valves, as they are called, would be pressed reduplicated into the auricle, if the muscular nipples or columns did not keep down their edges, and hold them firmly by their contraction (which is the same with that of the heart) in such a shape, as will extend the annexed chords of the valve, without injuring them. [After expelling its contents, the heart becomes quiescent, merely from the absence of a stimulus. For that the fibres can be able to dilate themselves, is contradicted by inspection, which assures us all the fibres of the heart exert their contraction at one and the same instant; and is no less repugnant to reason, which plainly shows us, that the transverse strings and fibres of the heart cannot act alone without the assistance of the rest.]

§. 99. But the nifus of the remaining blood in the ventricle, now resisted by the tricuspids, seeks another course; and, whilst it derives the larger of those valves, that is seated to the right, (§. 89.) from the side towards the axis of the heart, this leaves open the mouth of the pulmonary artery, which it before covered; whereupon the blood enters there, and, by pressing the valves in the mouth of the said artery close to its sides, it becomes thus filled and dilated by the blood driven into the lungs.

§. 100. To describe this more particularly, from the upper and posterior part of the right ventricle, a way leads into the *pulmo-*

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nary artery, which is strongly connected to the heart by a cellulous, callous ring, from whence the pulmonary artery ascends to the right backward, and displays itself behind the arch of the aorta. The strength of this artery is not extraordinary, being much weaker than that of the aorta. But from the inner surface of the artery, where it is joined to the heart, *three semilunar valves* arise, by a reduplication of the arterial membranes extended upwards and towards the axis, in an arch that is flat or obtuse enough; and these valves always fluctuate with their edges at free liberty, in a parabolical shape. The middle of the edges, in each of these valves, is generally divided by a small, dense, callous body of a conical shape, but made up of inclined planes, whereby each whole valve, in itself resembling an half moon, is thereby again subdivided into two less half moons. Betwixt the two membranes of the valve appear some muscular or tendinous fibres, partly in a transverse position, some of which hold fast the valve to the next contiguous side of the heart, leaving sometimes spaces betwixt them in a reticular manner. Other fibres ascend from the basis of the valve, and, by growing to the callous corpuscle, draw back the said valve, and open its concavity.

§. 101. Each of these valves, in conjunction with the sides of the artery here diverging, intercept a space, which is blind or impervious

pervious downward, but open upward in a parabolical shape, as we observed of the valves in the veins. (§. 53.) When, therefore, the blood is impelled from the sides towards the axis of the contracting heart, it endeavours to escape in the direction of the said axis, and, by rushing forth, like a wedge, betwixt the valves, presses their loose sail-like edges against the sides of the pulmonary artery, so as run freely out of the heart. The truth of this appears from the plain fabric, from injections, and from ligatures.

§. 102. The blood now received into the pulmonary artery, goes on then to make its circulation through the lungs. That artery is first divided into two branches, of which the left, being less and shorter, enters directly into the substance of the lungs; but the right branch, being larger and longer, passes transversely through the arch of the aorta, and after going a little way behind the said aorta, enters the corresponding lungs of the same side. From each of these branches, by a multiplied subdivision, arise the very least arteries, some of which transmit the blood directly into the continued small veins, and others exhale part of its aqueous juices into the pulmonary cells. That the blood goes thus directly from the arteries into the pulmonary veins, appears evidently from their structure; also from a ligature, which, intercepting the blood's course, while the heart and

lungs still urge it, causes an aneurismatic dilatation of the artery; and from polypusses, by which the mouth of the pulmonary artery being obstructed, the right cavities of the heart become monstrously enlarged, and at length burst, while the left remain empty. Lastly, from injections; for water, fish-glue, and milk, are very easily forced from the pulmonary artery into the vein, and from thence into the left cavity of the heart. But the direct anastomoses, or final openings of the arteries into the veins in the lungs, is proved even to the sight by the microscope, in frogs, &c.

§. 103. Nor can the blood, which has once entered the pulmonary artery, return back again upon the heart; because the valves therein (§. 100.) are of such dimensions, that, when distended, they perfectly shut up the opening at the heart, and are so strong, that they resist a much greater force than the contraction of the pulmonary artery, without being constrained to yield. However, sometimes, from a greater contractile force of the artery, they grow callous, or, from a laceration of their outer membrane, a bony matter is poured in betwixt the duplicature of the valves. For when the blood, by contraction of the artery, returns towards the heart, it meets and enters the open sail-like concavities of the valves, (§. 101.) which are, by that means, expanded and drove together towards an axis in the middle, whence
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the valves, once expanded, quite shut up the mouth of the artery, so as to leave not the least slit open; for any opening, that might be left, is præcluded by the small callous bodies, remarked at §. 100.

§. 104. The *pulmonary veins*, of which we shall say more hereafter (§. 272.) gather into larger branches, which, at last, terminate in four (seldom two) trunks; to which, it has been customary to affix a name in the singular, by calling them the pulmonary vein. These enter the cavity of the pericardium, from whence they receive an external covering, and are then inserted at angles into the square, left or posterior sinus, which is sometimes, likewise, called the pulmonary sinus. In this course, the upper veins descend, as the lower ones ascend. But that these veins bring their blood towards the heart, in the same direction with the sinus, into which they open, is proved by a ligature, which causes a tumescence or swelling, from the blood retained, betwixt the ligature and the lungs.

§. 105. This pulmonary sinus, being firmly built of divers bundles of fibres running betwixt two membranes, has forward, and to the right, one single side or partition, in common to itself and the right sinus (§. 82.); but forward, and to the left side, it goes into a conical appendix, which is divided into processes, or indentations, like a cock's comb, and, after two or three serpentine

turnings, makes, what is called, *the left auricle*, incumbent on the left ventricle. This sinus, with the left auricle, are somewhat less than the right sinus and auricle.

§. 106. In this left sinus the blood waits for the heart's relaxation, at which time the nifus of the blood, impelled against the venal valves, and the contracting stronger force of the sinus, grow less. Then the sinus, together with its small auricle, being contracted, the blood is, by their means, drove into the left ventricle, in like manner, as the right auricle impelled its blood into the right ventricle. (§. 90.) For here, as before, a like membranous oval ring forms productions called *mitral valves*, of which there are usually two only counted. These valves are longer and stronger than those of the right ventricle. They have each a muscular column, often single only, and joined to the tendinous threads of each valve; but they are much stronger than those of the tricuspid (§. 89.). And here callous knots or cartilaginous humours are often found in the tendinous strings, at their originations from the membranous ring.

§. 107. From what has been said then, it appears, that the same blood is now arrived into the left ventricle of the heart, which was a little before sent from the *venæ cavæ* into the right auricle, (§. 85.) which drove it into the corresponding or right ventricle, (§. 90.) by which again it was urged into
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the pulmonary artery, (§. 100.) and from thence, passing into the pulmonary veins, was conveyed into the left sinus (§. 104.); and out of this, we here find it driven into the left ventricle. (§. 106.) This course of the blood, from one side of the heart to the other, through the lungs, is called the pulmonary or lesser circulation, and was known to many of the ancients, before mentioned in §. 62.

§. 108. The *left*, or posterior and upper *ventricle* of the heart, makes up that part of its half-cone-like body, which we before called obtuse, (§. 86.). 'Tis somewhat narrower than the right ventricle, a little longer, rounder, and generally of a less capacity within. For the contents of this ventricle are about two ounces, while those of the right advance up to three. Its fabric internally is reticular, as in the right ventricle; but its force is considerably greater, as the muscular flesh that surrounds it, is much thicker and stronger.

§. 109. Again, this left ventricle, being instigated to motion by the impelled blood, does, from the same irritable nature before mentioned, (§. 87.) contract and drive its contained blood with a violent motion in the direction of its axis, and determine it towards the basis, at the time when the tip or cone of the heart is drawn nearer to its basis. And since the apparatus of the *mitral valves* is here the same, as before in the tri-

cuspid, (88, 89,) the venal blood now expanding the ring from whence they arise, removes that valve which lay against the mouth of the aorta, so as to open a way for itself to the artery, in dilating the mouth of which, the said blood presses the semilunar valves, there placed, against the sides of the aorta, into which it rushes with a violent impetus.

§. 110. The *semilunar valves of the aorta* differ little from those in the pulmonary artery, (§. 100.) only as the opening is here greater, so the valves are proportionably larger and stronger, and are not so often distinguished in the middle by those callous globules, or little round bodies. (§. 100.) The fibres too of the valves, both transverse and ascending, are here somewhat more conspicuous.

§. 111. But we must now consider, that these motions of the right and left auricle, with the right and left ventricle, are not performed in that succession, in which, for the sake of method, we have here described them; for both the auricles are contracted, while the ventricles are relaxed: so that the contraction of the auricles precedes the contraction of the ventricles; as we are assured from manifest experiments, on dying animals, and on those whose living blood is cold. But both auricles are filled together in the first instant as both of them are emptied together in the second instant; and both the ventricles are
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contracted together in the third instant, which is the same with the first; and both ventricles, being evacuated, are relaxed in the fourth instant, which is the same with the second. Those who have mistakenly taught otherwise, have not taken the advantage of making a sufficient number of experiments on living animals. That the auricle, near death, makes frequent palpitations, before the ventricle of the heart performs one contraction, is true enough.

§. 112. But it may be asked, why the heart never ceases from *its perpetual motion*, through such a number of years as there are in one's life, through so many days as there are in a year, and through so many hours as there are in a day, when, in each hour, the heart of a healthy person contracts not much less than 5000 times; so often are there successive repletions followed with new contractions, perpetually in the same constant order. [Nor is there any other muscle, besides the heart and diaphragm, but what becomes tired and painful, by acting incessantly, even for a few hours.] Different answers have been given to this question by different professors, founded either upon a compressure of the cardiac nerves betwixt the large arteries, or upon an alternate repletion of the coronary arteries, and cavities of the heart, &c.

§. 113. But to me the simplicity of nature seems very great in this matter. When the auricle is relaxed, it is directly filled by
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the muscular force of the continuous great vein ; and so the heart also contracts itself, when, in like manner, it is irritated by the blood driven into it from the auricle*. Therefore, the heart, having once received the blood, is contracted by that stimulus or irritable force, whereby muscular fibres are excited into contraction ; whereupon it empties itself of the blood, and, being freed from the stimulus thereof, immediately rests or relaxes itself. But the heart being now relaxed, the auricle is in like manner irritated by its contained blood, and by contracting fills it again ; while the incessant actions of the heart and arteries continually urge new blood into the right sinus and auricle. [The motion ascribed to the vena cava, is, from the right auricle, throwing back some blood again into the upper and lower cava, because the now dying heart will not receive it all.] That this is the true state of the heart's motions, is proved from actual experiment or observation, whereby we plainly discern the successive repletions and constrictions made in the

* Conformable to our author's system, was that of the ingenious Mr. Cowper, who allotted to the blood the office of a pondus, instrumental of the constriction, or violent state of the heart ; from whence (according to him) it spontaneously returned to its natural state of dilatation: though this is erroneously opposed by his friend Dr. Drake. Anat. Vol. II. Edit. 1. p. 403.

great vein, auricle, ventricle, and artery, easily seen in a weak or expiring animal, but more especially, and more evidently in those animals which have but one ventricle in the heart, as the tortoise, frog, snake, fishes, and in the chick hatching in the egg, which, instead of a heart, has only one crooked canal. The same is also confirmed from the resting of the heart, which follows upon tying the veins, and from the return of its motion, by removing the ligatures, or by the impulse of wind or liquors injected; and lastly, from the perpetual contraction of a frog's heart, round or upon a vesicle of air inflating it, which air urged into it by the vesicle, it will alternately receive, and for many hours transmit, into the common air. Hence it appears, why the auricles, and especially the right, are the last of all moving, if you except the next continuous part of the vena cava; because the heart is irritated into motion, by the blood sent towards it, by a contraction of the extreme parts from the cold invading the body, at which time, the lungs, destitute of the act of respiration, resist the blood of the right ventricle; but the left ventricle, receiving none, stands still for want of irritation.

§. 114. Nor do I believe there is any thing more than this required to the heart's motion. For if you derive the heart's resting, from a compressure of the nerves, the motion of the auricles will be an objection, whose nerves, in order to that, ought not to be

be compressed ; and for example, in fish and little chicklings in the egg, there can be no room for a compressure of the nerves. If, again, you deduce the heart's rest from a compressure, or occlusion of the coronary arteries, this is contrary to experience ; since they are not covered by the valves of the aorta, and from a wound of the said arteries, during the systole of the heart, the blood starts out to a great height ; and again, the motion of the heart still continued, after they were tied by M. Chirac. But such an absolute impatience is there in the fibres of the heart to bear any stimulus, that, even when the viscera are almost dead, this appears to have a kind of motion within its own fibres ; which, beginning in a sort of radiant points, is propagated in wrinkles into the adjacent parts : if, now, you pull out the heart, although it be growing cold, if you puncture, inflate, or irritate its membranes, the fibres of the extracted heart become corrugated in rings, notwithstanding there is not now a continuous nerve or artery to supply the beating heart. [And this irritability of the heart is more exquisite and durable, than in any other part of the body ; because we see, it may be thereby recalled into its former motions by a stimulus, when no other muscle can be so excited.]

§. 115. But with what celerity, and with *what force the heart* drives forward the blood, is controverted, and variously computed. The more modern writers have raised their
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calculations upon a supposition, that for the celerity to be determined, we are to admit two ounces of blood to issue out of the heart with such a celerity, that the part of the pulse, called its systole, makes one third of the whole pulsation, and is finished within a $\frac{1}{225}$ th part of a minute; but the area of the mouth of the aorta, they have estimated 0.4187 parts of an inch; so, by dividing the space filled by two ounces of blood, (3.318 inch) by the area or section of the aorta at its mouth, [and length of its cylinder filled by two ounces viz. $= 7\frac{29309}{33180}$] the number thence produced divided by $\frac{1}{225}$, the time in which the heart contracts, they find 149 feet and two tenths of an inch for the space, thro' which the blood runs in a minute, if it goes on in a cylinder with the same velocity it first had from the heart, which it does not. But the incumbent weight of blood moved by the heart, they have computed by the jet, wherein the blood starts forth from the larger arteries in a living animal, being seven feet five tenths, and from the surface of the ventricle, whose area makes 15 inches; which produce 1350 cubical inches of blood, or 51 pounds five ounces, which press against the ventricle of the contracting heart. The heart, therefore, thus drives forward a weight of 51 pounds, with a velocity, by which it may run through 149 feet in a minute; which force it exerts four thousand eight hundred times in an hour.

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There is no doubt but the heart moves not only the whole mass of blood, and other continuous juices, but also all the yielding solids, and even every individual yielding fibre is elongated by each systole: but then this is owing to the mechanism of the arterial system, which makes a lever or spring of very great purchase, for multiplying and transferring the force of the heart, which the arteries receive and apply, so as to produce great and extensive effects. But then we must not ascribe to the heart alone effects, which it can produce only by the assistance of the arteries. And if all circumstances be duly considered, the heart's force will be found so far short of Borelli's enormous calculation, that it will be less than any computation I have yet seen. See remark to §. 117.—As to the time in which the mass of blood may make a compleat circulation through the heart, as it flows with an irregularly decreasing and increasing motion, that varies in every artery, and in every vein, proportionably to their several lengths, diameters, angles, inflexions, strength, &c. no one can justly determine it. The return of it may be twenty times quicker through the coronary vessels of the heart, with those of the intercostal muscles and diaphragm, than in many other parts: and it may move an hundred times slower through the least vessels of the liver, than in the largest veins at the heart. However, on Dr. Hales's principles, the larger arteries may shift their contents into the veins, and the larger veins may pass their blood thro' the heart, once in about five or six minutes, in which time, the majority of the current passes the heart in one compleat round.

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§. 116. Although there are many particulars here (§. 115.) unthought of, which may render the estimate incomplete, and such, perhaps, as we may never get over; and, although, the area of the ventricle be of so uncertain dimensions, and the jet of blood computed from an insufficient height, yet, if we consider the violence, with which the blood starts from some of the least sanguine arteries in the living animal, although we cannot easily determine how much of the heart's systole it assumes to itself, variations, in which, will greatly alter the computation; yet, in the mean time, it will plainly appear, that the muscles we call the heart, make a very powerful machine.* The truth of this is evident from experiments, in which it appears to be very difficult to fill all the red blood-vessels by anatomical injections, and quite impossible to fill all the smaller of them: yet the heart, we see, not only gradually distends all the larger, the smaller, and even the least vessels with blood, but also drives it forward through them, with a considerable celerity. Even, from some of the least arteries, I have seen the blood start forth several feet, the jet describing a parabola, whose height was four feet, and amplitude of the projection seven feet. [And some assert, they have seen the blood ascend from the aorta to the height of 12 feet.]

* That is to say, when aided by, or acting in conjunction with the arteries.

R E M A R K.

Observe here, that the heart fills the smaller vessels, not by one, but by repeated strokes; or by a force multiplied in, and communicated from the coats of the great arteries, which force, as well as that of the heart, enters the measure or parabola of the jet of blood from an artery. See the following remark.

§. 117. Moreover, that we may make a just estimate of the heart's force in living animals, we must consider what great resistances that complex muscle overcomes; we must compute the enormous weight there is of the whole blood, a mass, perhaps, of fifty pounds and upwards: for all that quantity of fluids, once stagnant in a person lately drowned, or fainted away, are easily put into their former motion by the heart only. We must again consider the great decrease of the blood's velocity, arising from the greater light or capacity of the dividing branches, (from whence the ratio of its celerity, even in the intestines, may be computed to only a 24th or a 30th part of its original impulse) abates two thirds from the heart's force. And yet we see there are humours swiftly moved through much smaller vessels; as for example, in those of the Sanctorian perspiration, which, in a subterraneous cavern, I have observed to ascend swiftly in form of smoak or vapour; and the same celerity of the blood in the least vessels of little fishes, &c. is apparent to the eye
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by a microscope. Now since the frictions, in every machine, always consume a great part of the moving forces, much more do they in the human body, whose blood and juices are so much more viscid or clammy than water, and drove through vessels so small, that they permit only a globule at a time to pass through, and even hardly allow that, without changing their figure; but from so strong and extended a friction, must necessarily follow a very great hindrance to the motion, whence we may easily understand, that the force must be very great, which drives so swiftly such a prodigious mass of fluids, over so many resistances and decrements of the moving forces.

R E M A R K.

We are to observe here, that a very small part only of these resistances* is removed each time by any single contraction of the heart; to which the arteries serve as a multiplying spring, by their elastic force, proportionable to their distention; and drive forward the blood and its continuous juices, in the same manner, as the air, by its spring, throws out a continued stream with a celerity proportionable to its compression, in the fire-engine or forcing-pump. For, as the arterial valves at the heart, which sustain a part of this elastic force equal to their surface, will admit of various apertures; the heart acts upon that hydraulic principle, whereby *any force or pressure, ever so weak, by urging a fluid through an aperture, proportionably small, shall overcome any resistance, or raise any weight, ever so great.* So that whenever the arterial resistance is in-

* Equal to the opening of the valves.

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creased,

creased, or the muscular force of the heart abated, the valves of the heart are opened by a proportionably smaller column of blood; which, in a natural easy systole, is seldom more than half the contents of either ventricle; as in a natural easy expiration, the lungs seldom expel more than half their contained air. Hence it appears, that to allow an opening to the valves, equal to the light of the artery, and the quantity of blood expelled, to be equal to the capacity of the ventricle, §. 115. are concessions too great by half to estimate the natural force of the heart, which when reduced to but a few ounces, is yet, upon the abovesaid hydraulic principle, able enough to carry on the circulation. To this automatic or elastic force, as the principal, add the vital or muscular force of the artery. Vide remark to §. 44.

§. 118. The blood being drove into the aorta, immediately finds the two openings of the coronary arteries, which lie next the arterial valves, but above them, or within the aorta; and, in consequence of this, it rushes first of all into the said coronary arteries, by which the heart supplies itself with blood. These arteries are almost constantly two, which going off from the aorta next the heart, at an obtuse angle, are distributed in a retrograde or contrary direction. More particularly the *right coronary* artery descends betwixt the aorta and pulmonary artery, and bending round the surface of the right auricle, it winds about the sharp or anterior edge of the heart, whence spreading on the lower or flat side thereof, at its middle or a little

little further, the branches go on, and terminate towards the tip of the heart; after having first given its small branches to the right auricle and ventricle with the lower vena cava, pulmonary vein, &c. The other superior and *left coronary* artery goes out betwixt the left auricle and the aorta by three branches; one of which goes round the root of the left sinus to the lower plane of the heart, but terminates on this side the middle septum of the heart, and is spent on the left ventricle, and on the left auricle with its sinus. In like manner, another branch is spent by descending branches on the top of the obtuse edge or upper side of the heart belonging to the said ventricle, where it makes circles detached to the large arteries. The third branch is spent deep within the muscular flesh of the heart. All the external arteries of the heart are followed or surrounded with much fat.

§. 119. These arteries communicate, by open anastomoses, or inosculation of the small branches, every where about the septum and tip of the heart; but they nowhere make a compleat ring round the heart. They terminate in a two-fold manner.

§. 120. The first termination of them, is into the coronary veins, whose branches running in company with those of the arteries, have their trunks of necessity disposed in a different course. The *great coronary vein* is, therefore, a companion of the left coronary

artery; and is inserted with a large opening, secured with valves on the left side of the Eustachian valve (§. 84.) of the right auricle, the root of this surrounds the left auricle externally, and then accompanies the superficial branches of the left artery, as before described, §. 118.

§. 121. The other coronary vein (which you may make a part of the former, since they have both one common insertion) descends along upon the septum of the heart to its flat side; and may be properly called the *median coronary*. The *third* bends transversely round the surface of the right auricle, and then terminates within, or, at least, very near, the large opening of the coronary vein (§. 120.) anteriorly. This vein supplies that part of the right ventricle, which lies in the flat side of the heart; and often receives those nameless veins, we shall hereafter describe.

§. 122. There are still some other *anterior veins* of the heart; but one, more particularly large, goes along the adjacent edge of the right ventricle, and running for some length obliquely betwixt the membranes, is inserted into the most anterior part of the right auricle, and sometimes into the trunk of the upper vena cava. This anterior vein sends off another concealed one through the root of the right sinus, and being again inserted into the great coronary vein, it makes a compleat circle round the heart, like the
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arterial circle, (§. 119.) which some have described, but has not yet been seen by me. As for lesser venal circles about the heart, as well as the said arterial one, they are not yet sufficiently confirmed.

§. 123. But there are a great many more veins, uncertain in their number, which belong to the basis and internal parts of the heart, to which the anatomist has seldom any access, because they lie concealed betwixt the origins of the large vessels: and these open by numberless small mouths into the right sinus and auricle; and some, but a few only, into the left sinus. Thus I have seen a particular vein, which, from a latent sinus in the flesh of the right auricle, has ascended up towards the aorta and pulmonary artery, and inserted itself on one side into the greater coronary vein. Another I have observed, concealed betwixt the mouth of the coronary vein and the aorta, inserted into the right sinus; and another through the remains of the oval foramen, and septum of the two sinusses, inserting itself into the right sinus; and others again belonging to the venal valves, besides which, there are still others too numerous to describe.

§. 124. There are still more, and much smaller, veins in the heart, whose little trunks, being very short, cannot easily be traced by dissections; and these open themselves by an infinite number of oblique small mouths, through all the numerous foveæ or

little sinuosities and excavations, observable throughout the surface of the right and left ventricle. These are demonstrated by injections of water, wind, or mercury, made by the coronary arteries, after you have first tied their corresponding or accompanying coronary veins; or even by injecting into the great coronary veins, after you have first intercepted the openings of their largest trunks. For, in either of these cases, there are drops of the tintured water, bubbles of air, spherules of mercury, rushing out thro' the whole extended surfaces of both the ventricles of the heart. [And this, without any violence that can be supposed sufficient to break the vessels.]

§. 125. There are some who will have the coronary arteries filled with blood, not by the contracting of the heart, but of the aorta in its systole; which they think must be a consequence of the retrograde angle of the blood's course here, and the paleness of the contracted heart, with a supposition, that the valves of the aorta cover or close the mouths of the coronary arteries. But the two last of these are disproved by experience, and the first, or retrograde course, can only impede or lessen, and not intercept, the flux into the heart: for the injections of wind or mercury, into all the seminal and biliary vessels, demonstrate, that the large retrograde angles, which the vessels often there make, do not hinder the fluids from taking their

their natural course, though they retard it. But a proof, still more evident, is, that the coronary artery, and the blood starting from it, make a higher saltus at the time when the heart is contracting.

§. 126. Concerning the reflux or return of blood from the muscular substance of the heart, there is still less room to doubt: for all the coronary vessels discharge their blood into the auricles and ventricles, either right or left, (but less into the latter) by those larger (§. 120 to 123.) and by the smaller orifices, (§. 123.) as well as by the least, (§. 124.) which so easily transmit the injections, after you have first tied the larger coronary veins. The circulation through these vessels seems to be compleated in the shortest space of time that can be in any part, from the great velocity the blood receives from the heart itself, urging the same through its own substance. But that the whole contents of the vessels are cleared in each contraction, does not seem to me probable; for the blood-vessels of the heart do not look pale enough in that action to produce such an effect, as an entire evacuation. ---There is a very free or open passage from the arteries of the heart into the cellular substance, or fat which surrounds it.---If you ask, what are the uses of those least or shortest veins, which open obliquely thro' the surfaces of both the ventricles? (§. 125.)

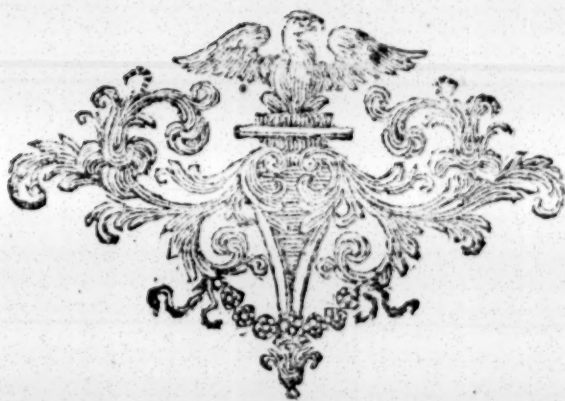
they serve to return the blood of those deeply seated small arteries, within the muscular substance, which have no corresponding veins running by their sides, like those on the surface.

§. 127. The humours of the heart, which are thinner than blood, return by the valvular *lymphatic veins*, which accompany the coronary blood-vessels, and ascend towards the thoracic duct and subclavian vein, but are very rarely to be seen.

R E M A R K.

From what has been said, it appears, that the force of the heart is manifestly greatest in those who have strong fibres, not too easily irritable, with a pulse large and moderately slow. For the number of pulses being given, the strength of the body, in health and disease, will be as its magnitude, if the arteries are duly pervious; and if the magnitude be given, the patient's strength will be as the slowness of the pulsations, if there be no obstructing cause at the heart. So the strength will be in a ratio, compounded of the magnitude and slowness of the pulse. Thus the person's strength, and the arterial resistance, with the tenacity of the humours, being the same, the quantity of the heart's contraction will be as its irritation, from the plenitude and tension of its ventricles. The arterial resistance and heart's plenitude being the same, its contraction will be as the nervous or muscular strength of the body. Or the heart's strength and plenitude being given, its systole will be as the resistances inversely.—If the heart weakened

ened throws out less than it receives, the pulse quickens to compensate the want of magnitude: and so the heart may labour with oppression, either (1.) from the venal pressure increased. (2.) From the arterial resistance augmented. Or (3.) from a nervous weakness of the muscular strength or vital powers. And these make the immediate causes of fevers, which result again from changes made by the nonnaturals, either in the automatic and muscular powers of the heart and arteries, in the encephalon and nervous system, or in the quantity and quality of the blood, and principal humours thence secreted.



LECTURE VI.

Of the common offices of the arteries.

§. 128. **T**HE blood is thus drove from the left ventricle of the heart into the aorta, which takes its course first a little towards the right, and then to the left in an arch, that is very sharply bent; and here the mass of this purple fluid strikes first against the right side, and is then reflected to the left side again of the aorta, whence flowing in a vortical or whirling motion, as much as that full vessel will permit, it goes on through the arteries, with an alternate collision against, and repercussion from their sides.

§. 129. These beating vessels are, in a living person, *always full of blood*; since the jet or stream, that starts from an artery, is not interrupted by alternate stops, while the heart rests or relaxes itself, but it flows on, in a continued thread; add to this, that the microscope shews the arteries, in living animals, to be full, both in their systole and diastole; nor can the circular fibres of the arteries so far contract themselves, as to entirely evacuate these tubes. Since, therefore, a new wave or column of blood is sent into the arteries already full, although it bear a small proportion to the whole mass contained in the arterial system, throughout

out the body, hardly ever exceeding two ounces; yet, by its immediate contact with the precedent wave or column, which moves slower, as it gets farther from the heart, it consequently drives the same forwards, and distends or dilates the arteries, urging the convex parts of their flexures outwards, and causing their spiral waves to be more serpentine, as injections demonstrate to us. This dilatation of the artery, whereby its light or capacity is changed from a less to a greater circle, is called the *pulse*; the *diastole* or dilatation of which, is an expansion of the artery, beyond its natural diameter. This being the proper or characteristic action of life, results from the heart only, and is in no wise natural to the arteries left to themselves. Hence, when the motion of the heart is intercepted, whether by aneurism, ligature, or otherwise, there is no pulsation of the arteries to be felt; and from hence too, there is a sudden cessation of the pulse, by a wound through the heart, in a living animal.

§. 130. The *systole*, or contraction of the artery, immediately follows the said dilatation of it. Namely, the heart, having emptied itself, and removed the stimulus of the blood, directly comes into a state of relaxation or rest. But the artery, at this same time, by its innate elasticity, and contractile power residing in its circular fibres, (§. 30.) irritated likewise by the stimulus of the

the impelled blood, enters into a state of constriction, by which as much blood is driven out from its capacity, as served to dilate it beyond its mean or middle diameter : which quantity of blood is either forced into the smaller and scarce beating arteriolæ, or else returned into the veins ; because the reaction, from the resisting semilunar valves of the aorta, will determine the blood that way from the heart, §. 104. So soon as the artery has freed itself from this wave or column of blood, being no longer stimulated by distention, it directly collapses by its own proper contractile force, and is now again ready to yield to a new wave or column of blood, sent into it from the heart ; whence follows a repeated diastole, or dilatation of it, as before.

§. 131. That the arteries thus contract, and, by that force, drive forward their contained blood, is proved evidently from their strongly contractile nature ; from the apparent diminution of the diameter or dilatation they receive from the heart ; from the evacuation that follows, by the proper force of the artery itself, driving out all the blood that is contained in the lateral branches, betwixt two ligatures ; from the greatness of the jet of blood, that starts from an artery, even while the heart is relaxed, and at rest ; from the strength or force with which eminent anatomists have observed the blood thrown out of the tied aorta, below the
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ligature; from the evacuation, which the arteries make of their contained blood, even after death, into the veins, whereby these latter appear much fuller than the arteries; and lastly, from the considerable jet or saltus of blood, that issues from a large artery in an animal, even after death, amounting to the height of two feet; to which add, the convulsive contractions of the animal, in which the artery is thus wounded, and the remarkable closings of the mouths of divided arteries in wounds, [and a sphacelation of the limbs, from an ossification of the artery; whence the veins become distended.]

§. 132. The great swiftness of the blood's motion, (§. 115) being such as carries it above two feet, in the space of a second of time, and the constant plenitude of the arteries, render it impossible for us to perceive any succession in the pulses of different arteries; whence all the arteries of the body seem to beat at one and the same instant, whilst the heart strikes against the breast; and yet there is certainly a succession in the systole of the arteries, by which the aorta seems to contract in the same order successively, as it is filled by the blood, expelled from the heart; so that the part of the artery, next the heart, is first constricted, and thence gradually the arterial contracting force proceeds to the extremities. An instance of this we have in the intestines, and the same is evident to the eye in insects, who have a

long fistulous and knotted heart, manifestly contracting in a succession from the beginning to the end. But the mind cannot distinguish the least points of time, which are the measures of this succession.

§. 133. If it be asked, where this pulsation ends? we answer in the least arteries, and cylindrical originations of the veins. Certain we are, that the lights or sections of the arteries, composed by the aggregation or sum of their transverse sections, as they divide farther, in their course, from the heart, greatly exceeds that of the aorta; so that since the ratio, or less proportion of the trunks to their branches, continually diminishes, as they make less ramifications, and this, in a variable or uncertain proportion; the difference of that ratio or proportion will be the greatest, betwixt the light of the aorta at the heart, and the sum of the sections of all the small arteries, where they are least, in the extreme parts of the body. Again, (2.) the proportion of the arterial membranes, or coats in thickness, with respect to their bores or capacities, is greater, as the arteries grow less; and is largest in the least of them, which transmit only one globe at a time. The truth of this, is proved from anatomy, and the forcing of air into the arteries, by which they burst always more difficultly, as they are less; and from the calculation itself, by which the magnitude of the least arteries is determined from

from the globules distending their two semi-cylindric membranes. Add to this, (3.) the friction of the juices through the least vessels, inflected and meeting together in angles; which friction, even in the most fluid water, running through long pipes that are single, and in a direct course, greatly diminishes the velocity, and more in proportion, as the tube is of a less bore; while again, as the artery is less, there are a greater number of globules rubbing and grating against its membranous converging sides. But, moreover, (4.) the *inflexions and folds*, or plates of the vessels, greatly slacken the blood's motion; since always some part of the impelling force is spent and lost in removing the convex parts of the folds, and changing the figure of the inflected vessel. Lastly, (5.) the great viscosity or tenacity of the blood itself must be considerably allowed for, since, by rest only, it directly hardens into clots; and since it is from the circulatory motion only of the blood, that this mutual attraction of cohesion, in its parts, is overcome, so as to hinder it from adhering together, or to the sides of the arteries; for so we find it adhere in aneurisims and wounds of the arteries, or else the globules clot together, as we see usually after death. From all which considerations, you will observe, that the blood meets with the greatest retardation in its course, in the least vessels. [And surgeons know, that a small branch,
near

near the heart or aorta, bleeds more dangerously than one much larger, that is more remote.] We may easily perceive the amounts of this retardation will be very considerable, although it be difficult to make a just estimate of it. In the larger trunks, the blood of a living animal flows with the rapidity of a torrent; but, in the least branches, it creeps along very slowly, with its globules trailing only one at a time, and apart from each other; so that in the least, it begins to put on a state of coagulation. Thus in a frog, the blood runs through the capillaries but two thirds of an inch in a minute; and in an eel, it moves through four inches in that time. Compare this with what is said at §. 58, 115 and 140.

§. 134. The pulse, therefore, or dilatation of the artery ensues, because the anterior wave or column of blood moves on slower, while the subsequent or posterior wave comes faster; so that the precedent is an obstacle to the consequent blood, §. 129. But since the force of the heart weakens as the blood goes on, and the contractile power of the arteries increases, therefore the disproportion of celerity, betwixt the antecedent and consequent waves or columns of blood coming from the heart, will be continually lessening, with respect to the blood that is urged on by the contraction of the smaller vessels, 'till arriving at a part where there is no excess or difference, it will there cease

cease to make any pulsation of the artery; because here the anterior and consequent blood flow evenly, or with the same celerity in one continued thread. But this place of equality, in motion, cannot be in the larger and more conspicuous arterial branches; for in them, the wave, last coming from the heart, moves quicker than what went before; as is evident from the inflammatory pulsation of them, especially in the small arteries of the eye. But in the least red arteries, the pulse at length begins to vanish. This is evident from the equable motion of the blood, often seen by a microscope through the arteries of a frog. But in the least veins, visible to the eye, there is no sensible pulsation or accelerated motion of the blood, whilst the heart contracts, demonstrable, either by the microscope or any other experiment.

R E M A R K.

With regard to the pulse of the arteries, it appears to us to depend more on the action of the arterial coats than is commonly imagined. For example, if the parts of a viscid fluid run into cohesion, so as wholly, or in part, to shut up the light of a converging tube, this will be so far from accelerating the flux through the dead tube, that it will either proportionably abate, or wholly intercept it; whence the doctrine of inflammation, as arising from a mere obstruction, has been exploded by Dr. Gorter and others (who, by standing on good preceptor Boerhaave's shoulders, have, in several

particulars, been able to see further than himself.) But an obstructing matter in a living artery, which is an irritable muscle of considerable force, will there act as a stimulus, whereby a greater flux being derived into the nervous and vascular fabric of the arterial coats, that obstructed artery will contract more violently, or to a less diameter than the rest, as will, likewise, all the branches coming from the artery below the part stimulated: but this series of the arteries being thus more empty than others at each systole, as soon as their contraction is over, they will proportionably make a less resistance than other arteries, to the blood that comes to fill them; which, thus flowing in a greater quantity, will also cause a larger diastole, which, joined with a larger systole, is the essence of fever and inflammation. We are, therefore, not to imagine, the blood is equally accelerated through all the arteries in fevers; for wherever there is pain or local inflammation, the acceleration will be greatest through the arteries of that part; although, from communication and consent, it will be also accelerated in a less degree through the whole system. Dr. F. Hoffman makes this local and universal increase of action in the arteries, the proximate cause, not only of fevers and inflammations, but of most other disorders, under the denomination of spasms or convulsive constrictions; and contents himself in accounting often for the production of a disease, by resolving it into this source: whence his theory is less useful and instructive than the Boerhaavian, which takes particular notice of, and classes more accurately, the many proximate causes in the habit, and numerous remote ones without, producing this spasm as an effect; the cure or removal of it being various, as the causes shall direct. See remark to §. 44.

§. 135. It follows, therefore, that the force of the heart altogether ceases in the beginning of the veins, since there is very little of it remains in the least arteries, and in the least of the conspicuous veins, nothing at all of it can be found. And that the pulse may be thus spent or lost, merely through the narrowness of the least vessels, is proved by the experiment, in which a pipe, fixed in a leathern tube, and driving forth water in a continual, but starting stream, does, by a sponge, fixed round the mouth of the said tube, cause the water to issue forth in an even stream, without leaping, through the sponge: and the same is evident from another experiment, in which the same thing happens, by injecting the mesenteric arteries with an alternate impulsion of water; for then the water flows out through the veins, in one continued even stream.

§. 136. The *pulse* is, therefore, the measure of the powers, which the heart spends on the blood; because it is the immediate and full effect of those powers. Hence all things considered as alike, the pulse is *slow* in the most healthy people, where there is no stimulus, nor any unnatural resistance to cause the effect of a stimulus, but the heart is at liberty to send forwards the blood with ease. A *large* pulse is caused by fulness of the artery, joined with a strong force of the heart. But a *hard* pulse denotes some obstacle or stimulus; or else, that the heart's force is increased with a greater thickness of blood, or a greater rigidity of the artery. A *quick* pulse denotes some stimulus,

obstacle, or greater sensibility or irritability of the heart. 'Tis best felt where the artery lies exposed bare to the touch, upon some resisting bone; but obstructions sometimes render the pulse perceptible, where it is never so naturally.

§. 137. The pulse is slower in animals, as they are larger or more bulky, [because the heart is proportionably bigger in the smaller than in the larger animals] and because the heart is obliged to drive the blood to a greater distance; whence the resistances or frictions seem to be increased, in the more bulky, over the force of the heart. Hence, small animals are more voracious, and large ones, as the whale and elephant, eat less. The pulse of a healthy person, rising in the morning, beats 65 in a minute; but, after the fatigue of the day, it will in the evening beat 80 in that time; and again, by the night's rest or sleep, it will become gradually less frequent, 'till, in the morning, you will find it returned again to its primitive number of 65. For the voluntary motions of the muscles, and actions of the external and internal senses, urge the venal blood on to the heart, which, being thereby oftner stimulated, makes more frequent contractions. This is the cause of those paroxysms or fits of increase, observable in all fevers towards the evening. For sleep not only retards the motion of the blood, but of all the other humours and actions in the body whatever.

R E M A R K.

This is one of the curious observations of Dr. Hales, viz. that the pulse is quicker in small animals, and slower in larger. In his *Hæmastatics*, he found the pulse of a horse slower by half than in a man, viz. 32 only in a minute; whereas in a dog, the pulse beat 97 in that time; and in a sheep 65, i. e. about the same as in a man sleeping. And this we see is conformable to the blood's heat, measured by the mercurial thermometer of Fahrenheit's scale, as the late Dr. G. Martine has ingeniously observed. For the blood in oxen, horses, and other large animals at rest, being five or six degrees cooler than in us, will not rise to our heat, i. e. gr. 96, but by a tolerable degree of exercise or labour, which they can thus better endure: whereas dogs, cats, and fowls are five or six gr. hotter than we (viz. about gr. 102.) and the latter, when sitting or brooding on their eggs for young, are still four or five gr. hotter, viz. 107 or 108, which is commonly the heat of our blood in the fit of an ague; where it is observable, that during the greatest sense of cold-chill, the blood is three or four gr. hotter than in health, after which it gains four or five gr. more in the height of the hot fit, viz. gr. 104 or 5; but in violent ardent fevers, where the pulse beats 140, the blood's heat will still be four or five gr. higher, viz. gr. 110; i. e. two or three gr. more than equal to a brooding hen or pidgeon, and within three gr. of the heat that scalds a delicate or tender hand. But such an heat is in no danger of hardening, but of putridly dissolving the blood or serum, which our good preceptor Boerhaave mistook in his chemistry; for to indurate serum or the whites of eggs, takes near 50 gr. more of heat. Nor is the pleuritic or inflammatory crust caused by a greater

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heat, but from a greater stagnation of the blood in some vessels, while it runs faster through others; by which the lymphatic and serous globules, with the nutritious glue, §. 15. retaining less motion from their less density, run into filamentary conceptions and cohesions.

§. 138. The pulse is more quick or frequent in children, as they are younger, and becomes afterwards slower in persons as they grow older. The salient point of an ovum beats 134 in a minute: new-born infants have their pulse 120 in that time, and from thence down to old age it grows slower, to 60 in a minute. A feverish pulse begins from 96 per minute, and we count the pulse has but a moderate celerity in fevers, or laborious exercises of adult persons, if it does not exceed above 110 or 120 in a minute; but 'tis excessive at 130 or 140, which is the number of the pulse, with which a person dies. The pulse beats slower in winter, and quicker in summer, by about 10 strokes per minute; and under the torrid zone, it grows quicker to 120. The different passions of the mind variously accelerate, retard, and disturb the pulse.

R E M A R K.

Here we may observe, that the blood's heat or its velocity are neither of them, in all cases, proportionable to the quickness of the pulse; but more density or proportion of crassamentum in the blood, with more magnitude of the pulse, or distention and elastic force of the arteries must concur; the defect of which is a balance to the great celerity of the pulse in infants, which would otherwise be the cause

cause of a high fever in them, as well as in adults. But as they make all their own red blood, even in the womb, and receive none from the mother; the largest globules which generate the heat, and the elastic force of their vessels, are at first inconsiderable, and as these advance by age, the celerity of the pulse abates; whence the heat and velocity of the blood are continued nearly the same.

§. 139. Through the least veins the blood moves on very slowly, partly by force of the heart, which, in some measure, still remains in it; and partly, by the contractile force of the arteries. The first is proved by a renewal of the motion of the blood, in persons drowned; where, merely by exciting the action of the heart, the whole mass is driven forwards. But the contractile force of the artery is proved by the sphacelation of the limbs, whose arteries are become ossified; [by the continuation of life from this force, after the heart has been ossified or consumed; and again, from the blood continuing to move by this force in the tail of a frog or fish, after it has been cut off sometime]; from the turgescence of the veins in general, and particularly in the liver, by this force; and from the progression of the blood, in a tied artery below the ligature, into and through the veins of any limb to the heart, by whose force it cannot, therefore, in that case, be drove on. But the different small times of these arterial contractions cannot be distinguished by the eye, they are so very minute, though reason assures us of their difference; and as to any perceptible difference in the larger veins,

that is confounded by the actions of the adjacent muscles and incumbent arteries, §. 141. [But after death, the blood continues to move, in part, also by its own gravity, and by the elasticity of the air generated, or extricated by putrefaction.]

§. 140. But the blood moves on faster in the larger veins. For whenever the impelling powers remain sufficient or the same, and the conveying small vessels are rendered narrower, the motion of their contained fluids must of course be accelerated; since the section of the venal trunk is much less than that of all its branches, in the same manner as that of an artery is less than the sum of the branches into which it divides. Therefore, if the motion of the venal blood loses nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth division, will be thirty times greater in the former, in proportion, as the conjunct lights of all the small veins exceed the light of the cava. In like manner too, the friction or attrition of the blood in the veins, and its contact with their sides, diminish.

§. 141. But since the blood moves thus slowly in the least arterial vessels and incipient veins, and as the weight of the blood itself, in many places, wonderfully hinders its return to the heart, while, at the same time, the very thin coats of the veins have but little contractile power to be expected from them; therefore, nature has used various precautions, lest, from the slowness of its motion, it should any where stagnate

stagnate or concreet. To obviate this, she has not only furnished them with valves, but also supplied the veins with more watry vapours and fluxile lymph, than she probably sent by the arteries, if we consider the great exhalation that is made from the arterial blood in the lungs.

§. 142. She has, therefore, likewise placed the veins near the muscles, that, by the turgescence or contractions of the latter, the veins may be pressed; and since, by reason of the valves, (§. 52 to 57.) any pressure upon the veins must be determined towards the heart, (§. 55.) therefore all this force will be entirely employed in accelerating the return of the blood to the heart. From hence proceeds that wonderful quickness of the pulse, (§. 137.) heat, and redness of the body, with a short and laborious breathing, that attends the muscular motions or violent exercises of body.

R E M A R K.

The contractions of the aorta appear to urge forwards the blood from the heart, by successively acting towards the extremities; whence the elasticity of the arteries proves a great help to the motion of the blood, and for keeping it in an even stream, like the jet of a fire-engine. In a state of rest, the veins usually contain above twice as much blood as the arteries; and as they easily dilate upon violent exercise, by which the larger arteries become almost empty, but the smaller very full; they will, upon occasion, enlarge their capacity with respect to that of the arteries, as two and an half to one, which proportion they show by injections; but then you must consider this, as a state
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of the utmost violence and fulness. However, upon occasion, the veins will, without much difficulty, dilate, as a reservoir to the right side of the heart, sufficiently to hold four or five pounds of blood above their usual quantity, that in rest serves to fill the larger arterial trunks. For unless there was a provision for this redundant quantity, which, by violent exercise, is brought from a slow motion in the cells and least vessels, into a quick rapid circulation in the trunks and large branches, the animal used to much rest would, by violent exercise, be suffocated by a rupture or other extravasation in the lungs, brain, eyes, liver, &c. where the vessels resist least, or are of the tenderest fabric. This being considered, as there is so ample and wise a provision for preventing the fatal effects of sudden fullness, by the easy dilatability of the veins, I am persuaded, many of our modern apoplexies come from one or both the carotid or vertebral arteries, being cramped with a convulsive force, as in other muscles, by which they urge forwards their contents, from the part where the cramp begins, with such violence, as suffices to cause a rupture or extravasation from the extremities of that trunk: and this is the reason, why bleeding is often of so little use to remove the cause, which would sooner remove by a more painful stimulus, (as some burning cinders put directly to the hands or feet, 'till blisters, purges, clysters, &c. can be got). In a word, as nervous disorders have increased upon us of late years to an astonishing degree, so most of our apoplexies, of late, are of the nervous kind. A similar arterial cramp in the lungs causes an hæmoptoe and asthma; in the liver, a jaundice; in the gula and alimentary tube, the hip and hysterical fits, &c.

§. 143. Moreover, those muscles, which constantly purge or press violently the contiguous viscera on all sides, that are contained in any of the common venters or cavities, do all of them powerfully promote the return of the venal blood to the heart. Such an effect has the conjunct pressure of the diaphragm with the abdominal muscles, in respect to the abdomen. Lastly, the pulsations of the arteries, which run every where contiguous and parallel by the sides of the veins, have no inconsiderable effect in promoting the return of the venal blood; since, as we have before shewn, any impulse, acting on the veins, can determine their blood to the heart only. V. §. 53 to 57.

§. 144. By these means, a sort of equilibrium obtains betwixt the arterial and venal system, and betwixt the trunks and their branches, whereby the blood in a healthy person, using sufficient exercise of body, moves on with such a velocity, as suffices to deliver as much of the purple fluid in every pulse by the vena cava to the heart, as is equal to what is sent out by that great artery the aorta. But rest or inactivity of body, and a weakness of the contracting fibres of the heart and other muscles (among which, the arteries themselves (§. 44.) are included) frequently render this motion of the venal blood more difficult. Hence follow varices and the piles in women with child; which latter is much occasioned from the deficiency of valves, in the veins of the porta. And from hence spring, even the symptoms of fullness, and the menses themselves. And
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when the veins too slowly return their blood to the heart, the subtle vapours from the least vessels irrigating the parts, being thus resisted, or scarce able to return to the heart, are obliged to stagnate; whence proceeds that frequency of œdematous and pitting swellings of weak people.

R E M A R K.

The contents of this section are of the last importance, as a general key to the more proximate causes, and the most rational treatments of diseases in general. We see hence, that the way to health is in moderation betwixt too much or too little motion or circulation of the blood, and its juices, through the vessels; to attain which, a person must dedicate, at least, one third of his life to sleep, another to brisk exercise, and the remainder to rest and refection: excess or neglect in either of which, in conjunction with other causes, will, by subtracting too much from the blood's motion, hasten one's end, by chronical and nervous diseases; or, by too much acceleration of its motion, will have the same effect, by acute inflammatory diseases, and their consequences. An idle person, that lives plentifully, shall breed too much juices, which will lodge where there is the least motion and resistance, i. e. in the cellular substance and smaller vessels; if now, by a little more heat and exercise than usual, these are driven into the larger trunks, which have a small ratio to their branches, a suffocated plethora (*ad vasa*) is changed into one excited (*ad vires*); the consequences of which are pains, hæmorrhages, fevers, and symptoms without number; because a plethora soon causes a cachochymia, &c.

§. 145. The *effects* which follow from the motion of the heart and arteries upon the blood, are various, which may be deduced and estimated from the causes themselves of those effects: if we compare together the blood of a living and of a dead animal, that which is healthy with that which is diseased, and that which is inert, or too little moved, with that which circulates too swiftly.---For we observe, that, in the living, the blood is, (1.) Considerably warm or hot. (2.) It looks red, with a sort of purple florid hue. (3.) It seems to be homogeneous or uniform, and alike in its parts, though they are really mixed, and of different principles. (4.) 'Tis made up almost entirely of globules. (5.) It flows very readily thro' the least vessels; from whence being drawn, (6.) it exhales a volatile vapour, which we shall particularly describe, §. 155.---In the dead animal, which has not yet begun to corrupt or putrify, we observe, (1.) that it has lost a great deal of its redness. (2.) That it separates into a more dense and a more thin substance. (3.) That it exhales no vapour. (4.) Being drawn out from the veins, it congeals either all or the greatest part. But even in the living animal, when very weak, where there is some pulse or respiration, though small, we find the blood cold, even to a considerable degree. If, again, you compare the blood of a human person, unactive both in body and mind, with the blood of one that is addicted to violent exercise, you will observe the latter has, (1.) A greater heat. (2.) A more intense redness,

redness. (3.) A substance more compact, and specifically heavier. And, (4.) The volatile parts more abundant. All which appearances seem manifestly the effects of the motion of the heart and arteries, since they proportionably increase and diminish with that motion, and disappear when that ceases.

§. 146. That we may understand the manner in which these appearances are produced, in the blood, we must consider what are the effects of the heart impelling the same, and of the arteries alternately compressing and urging it forward. And first we see, that the heart drives the blood into the arteries with a celerity which exceeds that of the most rapid rivers, (§. 115.). With a confused or vortical motion, the heart thus throws the blood into the crooked or inflected arteries, in such a manner, that the right globules, expelled through the opening of the aorta, strike against the left side of the artery, from whence being repelled, they incline towards the right side, whereby all the particles of the blood are agitated with a confused or turbulent and whirling motion. The blood, thus impelled against the flexible and curved sides of the arteries, of necessity dilates or distends them into a greater convexity; and lastly, in the smaller vessels, capable of receiving only one or a few of the blood-globules, all the said globules come so intimately into contact with, and grate against the sides of the said artery in all their points, that they are even obliged to change their figure, in gaining a passage into the veins.

§. 147. But the arteries, by their elastic force, reacting upon the impinging blood, repel the same from their sides towards the axis of their light or capacity; and, at last, transmit every single particle of it through the circular mouths of the least vessels, by which the arteries and veins join together.

§. 148. There is, therefore, a most prodigious degree of friction, as well of the blood-globules against the sides of the arteries, as of the arteries themselves, contracting round the blood, like an obstacle; to which, add the attrition of the particles of the blood amongst each other, by the confused and vortical motion with which they are propelled. The effects of this friction may be computed from the viscid and inflammable nature of the blood itself, from the narrowness of the vessels, thro' which it runs, and from the strong impulsion of the heart, joined with the powerful reaction of the arteries; to which, add the weight of the incumbent parts, raised by the force of the arterial blood. This friction generates a fluidity in the blood, by perpetually removing the points of contact in its globules, and resisting their attraction of cohesion. By deficiency herein, the blood coagulates in the vessels before death; and from hence, the lost fluidity of the blood is again restored, by recovering the motion of the heart, as we are taught by experiments made on living animals. We must, likewise, own it for the generating cause of heat, which constantly arises from an attrition of the parts of all fluids, even of air itself,
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by experiments ; but much more does this attrition heat in the elastic and combustible animal juices, which are denser than water, and compressed with a considerable force, by contractile and converging tubes. [Is not the truth of this sufficiently evidenced, by the blood's being warm in those fish which have a large heart ; and cold in such as have a small one ? from the more intense heat of birds that have a larger heart, and more frequent or quick pulsations ? and from the increase of animal heat, that ensues from exercise of all kinds, and even from bare friction of the parts ?] That this animal heat is generated chiefly in the lungs, we are persuaded by many arguments, which we shall propose, when we come to speak of the respiration. At the same time, by this rotation and mutual attrition, the particles of the blood acquire their spherical figure ; and even the filamentary, rough, and irregular shaped particles, having their eminencies, in a great measure, ground smooth, approach nearer to the nature of spheres. But again, the fragments, from the surfaces of the irregular shaped particles, will, by this friction and rotation, with the spherical lights of the smaller vessels, put on a round figure.

§. 149. But the different natures of the several particles themselves, which conjunctly make up the mass of blood, are the causes whereby, from one and the same impetus of the heart, different effects or consequences are produced in different particles of the blood. Namely, those particles move quicker, whose greater

greater density makes them receive a greater impetus, and whose apt figure or less extended surface makes them meet with less resistance in the fluid, in which they move. Those also are drove along more swiftly, which, either from their weight, or from the direction in which they pass out from the heart, are urged chiefly into the axis of the vessel. Those again will strike against the convexities of the flexures in the arteries, which have the greatest projectile motion; while the other parts of greater bulk and tenacity, having less projectile motion, will move sluggishly along the concavity of the vessel. And, in this manner, is the blood prepared or disposed for the several secretions.

§. 150. The systole of the arteries renders the parts of their contained fluids more dense or compact, while they contract round the blood, as round a solid obstacle, which being in some parts viscid and compressible, they drive and expel the more liquid parts into the lateral mouths or ducts, at the same time increasing the points of contact betwixt the globules themselves, uniting together their more large and dense spherules, and compacting the flat particles into denser bodies. From this density, the redness of the blood seems chiefly to proceed; for that it is not merely the effect of the lungs, we are assured, from observing the same in fish, who have no lungs; but that the blood's redness follows from its increased density, we are assured from the philosophical laws and optical experiments of Sir Isaac New-

ton ; and from experience itself, which shows us, that both the density and the redness of the blood are always increased together, by increasing the exercise and motion of the muscles, or even barely by accelerating the jet or stream of blood, that descends in a large arch from the vein into a vessel.

§. 151. Moreover, the mouths of the least vessels, pervious to only one globule at a time, seem to be a sort of moulds to figure and break off the angular eminencies of the particles in the blood, and bring them to a spherical figure, which, at length, they put on, and change into perfect spherules. Lastly, from hence arises the density of those particles, since of all figures, spheres contain the most, within a given surface.

§. 152. The *reticular* distributions and inosculations of arteries (§ 37.) removes any danger of obstruction, since, in any part of the artery, where the blood cohering, begins to form an obstruction, a contrary flux is admitted, whereby the obstructing matter is repelled to a larger part of the trunk, and thus, betwixt the reflux and the direct torrent of the blood, the said matter is broke and attenuated. This mechanism also supplies the deficiency from an irremoveable obstruction or the loss of a vessel, by causing a greater distention or enlargement of the next adjoining or anastomosing vessel ; as is proved by experience in surgery, after tying and cutting a great artery.

§. 153. As the quicker motions of the blood in the trunks conduce to sanguification, so the
flower

flower motions of it, in the least vessels, have their effects towards the secretions. In the larger arteries, we see the different particles of the blood are whirled about amongst each other, with a rapid and confused motion; but, in the lesser ramifications, the progressive motion of the blood being diminished, the more loose colourless particles depart laterally from the more dense and red globules, while the latter, keeping on their course more firmly along the axis of the vessel, expel the former laterally, and to the circumference. Thus the attractive powers of the particles in the blood increase, as their progressive motion abates; hence, the oily or fat particles are drawn one to another, and go off by the open lateral ducts, which lead to the cellular substance, which particles we know are both gross and sluggish: and again, other thinner juices are sent off through lateral branches of a much smaller orifice, 'till, at length, little more than the red blood alone remains to pass through the evanescent artery, into the incipient vein. But all these particulars, whereby the blood is disposed for the secretions, we shall consider more opportunely hereafter, in *Lecture VIII.*

R E M A R K.

Dr. Clifton Wintringham, in his experimental enquiry concerning the arteries and veins, has given us several observations worthy of notice; the principal of which are, That the veins are denser in their membranes than the arteries: the aorta of a young man dead 48 hours weighed to water as 106 to 100, and the vena cava to water was 110 to

100. The thickness of the aorta was one ninth of an inch, but of the cava only $\frac{1}{34}$ of an inch; so the artery appears thicker than the vein as 17 to one. Thus the arteries being less dense than the veins, are better adapted to continue the actions of life a longer time, without growing rigid and bony or cartilaginous, by the impulse of the blood against their sides: for had the arteries been originally as dense as the veins, the animal could not have lived so long. For, by his second proposition, it appears experimentally, that the arteries are more dense and rigid, as the animal grows older, whereby, when their resistance equals the distensible force of the heart, they determine the size and growth of the person, (§. 252.). For in young persons, the vessels are obliged, by their conical figure, to yield more in length, than diameter, to the distending force of the heart; but when the firmness of the arterial coats can sustain the impulse of the blood, without an elongation of their fibres, the person grows no taller. As those arteries, which spring nearest from the aorta, have a greater share of the heart's impulse, they are therefore more dense than their next collateral or smaller branches, which, being gradually more lax and easily distensible, is one cause of the blood's flowing so readily from the trunks into the arterial branches. Thus, generally, the fluids prevailing over the solids for the first 20 years, the person will be so long growing; and then, for 20 years more, the person will be nearly at a stand, from the equilibrium of the solids and fluids, which now admit only a lateral distention, by which the person grows not in height, but increases in bulk (which is not properly growth, as it springs not from any solid concrement, but an accumulation of fat and juices, that was formerly spent in growth); and then, for 20 years more, the solids, by repeated action, being grown

too

too dense, the equilibrium turns on their side, the fat and juices, formerly collected, are now consumed and expelled by the greater power of the vessels; and, as we see from experiments, the smaller vessels, concreting into solid fibres, make the arterial coats much thicker and tougher in old, than young subjects: in consequence of this, the force, to excite any degree of motion in young animals, must be increased to produce an equal effect on the fibres and vessels of an old one. Hence we see a greater influx of spirits is necessary to actuate the organs of an old person, which yet cannot be now secreted by a brain more callous and impervious, from a blood lessened in its proportion, ill-circulated and ill-formed by a weakness and inactivity, now obtaining in both the sanguificative and chylicative organs, &c. Hence a ceasing of the fecundity and menses in women, a collapsed or shrivelled habit in old men, universal torpor, tremors, &c. And these experiments also furnish one reason, why consumptions, from a rupture of the pulmonary vessels, seldom happen before the age of 20 or after 40; because, in the first stage, the redundance of juices is employed in the growth; and, in the last, the over dense fibres and vessels do not so easily break or yield to the impelled fluids.—An inch of the aorta from a young man burst with the force of 131 pounds, 10 ounces. The aorta of males is near a fifth part denser and tougher than in females; but the veins, as in the cava, only a sixth or seventh part. But even the aorta is less dense, or more easily dilatable near the heart, than its branches. So by experiments, we see it is a just observation of Dr. Pitcairn and Friend, that the inferior series of vessels are proportionably more capacious (a fifth or sixth part) in females than males, and in comparison with the upper series of vessels; whence a greater flow of blood for the foetus and

menfes. But the veins in females are smaller, ſo that the blood moves faſter in a woman's veins, and ſlower in her arteries, whereby its fluidity is better maintained, and its texture leſs vitiated by the numerous obſtructions that attend geſtation.—The extraordinary capacity of the cava above the emulgent, beyond that of the aorta, being nearly as two and an half to one, makes it of ſingular ſervice as a reſervoir to collect the blood, or ſupply the heart in weakneſs, and prevent a ſurcharge in running, ſtraining, fullneſs, fevers, &c.—Anatomiſts have erroneouſly ſuppoſed the ſtrength of arteries and veins to decreaſe in proportion, as they grow leſs in thickneſs; for, by experiments, it appears the thinneſt veſſels have often a much greater degree of compactneſs and ſtrength, proportionably than the larger; and ſome whoſe coats are extremely thin, exceed in ſtrength the aorta, whoſe coats are ten times as thick. The emulgent artery was found a fifth or ſixth part ſtronger than the aorta at the heart; and the emulgent vein was two thirds ſtronger than the cava. The porta was ſtronger than the ſplenic vein nearly as 5187 to 1000. The ſplenic artery was ſtronger than the iliac nearly as 148 to 100; but the iliac vein was ſtronger than the ſplenic as 35 to 10 nearly; and the emulgent artery was ſtronger than the iliac artery as 1376 to 1000. In a word, the arteries are infinitely diverſified as to their ſtrength and capacity, obſerving no regular proportion; whence it is abſolutely impracticable to account for the ſecretions thence.—The veſſels of the pericranium, dura mater, pleura, and all denſe membranes, eſpecially thoſe attached to bones, ſhall have a violent degree of pain from a diſtention, that will not affect other veſſels; becauſe the former, yielding in points leaſt reſiſted, will not dilate in a ſphere, but an ellipſis or a leſs figure; whence the
reaction

reaction of the resisting parts will be turned upon those that yield, whereby the distraction and pain will be double, if only half the vessel can dilate. Hence we see, why pain may be in some vessels and not in others, coming from the same trunk, and urged by the same distending cause: and why pain is more violent in strict, tense habits, than where the the fibres are lax, &c.



LECTURE VII.

Of the nature of the blood and juices of the human body.

§. 154. **T**HE very complex liquor, which is contained in the beating arteries and their corresponding veins, is called, by one general name, the *blood*, which, to a loose examination, appears homogeneous, or of similar parts, red and coagulating throughout. But experiments of divers kinds have shown us, that dissimilar parts of various natures reside in the composition of this animal liquor.

§. 155. Hydrostatical experiments demonstrate in the blood first a kind of volatile vapour or exhalation, which immediately and continually flies off from the warm juice, with a sort of foetid odour coming betwixt that of the sweat and urine. This vapour, being caught and condensed in proper vessels, appears of a watry nature, joined with a small tincture of an alkaline disposition.

REMARK.

This halitus of the blood consists of an ammoniacal salt, so attenuated as to be volatile, without altering its nature much to the alkaline class; which, joined with a small portion of oil and much water, affords that remarkable nidorous smell upon opening a dog, hog, or other carnivorous animal, whilst warm; for in oxen, sheep, calves, &c. feeding on grass or grain, it has scarce any perceptible smell;

smell; but in mankind, it has a very particular odour, flying off chiefly in the perspiration, by the scent of which, every dog can distinguish and follow the foot-steps of his master.

§. 156. After this vapour is gone off, the blood of a healthy person spontaneously congeals into a scissile trembling mass; and with a less degree of heat than that of boiling water, (viz. 150 gr. i. e. 62 less than boiling water) it grows more tough, like to a boiled egg. But even within the vessels of a living person, dying of a fever, the blood has been seen by the violence of that distemper, changed into a concreted tremulous jelly throughout all the veins. The principal part of this coagulated mass, is the *crassamentum* or *cruor*, which has the red colour peculiar to itself, and gives it to the other parts of the blood. This, if it be not kept fluid by the attrition of a vital circulation, or some similar concussion, runs confusedly into a compact, but soft mass, merely by rest and a moderate degree of cold, as it also does by the addition of alcohol, by mineral acids, or by a heat of 150 degrees, [of which 98 is the blood's heat in robust people; 175 boil alcohol vini; 190 boil proof brandy; and 212 boil spring water.] 'Tis either as a fluid or a solid specifically heavy, and more so than water, by near an eleventh part; and when freed from its water, it is wholly inflammable. In a mass of healthy blood, one half or upwards is red cruor; and in strong laborious people, the serum makes only a third part, and is still
more

more diminished in fevers, often to a fourth or fifth part of the mass.

§. 157. Next to this comes the white or clear and the yellowish part of the blood, which again seems to be a liquor, consisting of homogeneous or similar parts, when it is not really so. This *serum* (as it is called) of the blood is, in general, one thirty eighth part heavier than water, and almost a twelfth part lighter than the red globular mass of crassamentum: this too, by an heat of 150 gr. or by mixture of mineral acids or alcohol, and by a concussive motion is congealable into a much harder coagulum than the red cruor (§. 156.), or mixed mass (§. 154.); and forms an undissolvable glue, a flesh-like membrane, which, at length, shrinks up to a horn-like substance. From thence are formed the pleuritic crust or skins, polypusses and artificial membranes. In this serum of the blood, besides the albumen, which will harden like the white of an egg, there is concealed a great deal of simple *water*, which even makes the bigger part of the whole, and some quantity of a ropy *mucus*, drawing out into long filaments, like spiders threads; which last, however, is not coagulable like the albumen, neither by fire nor by acids.

§. 158. But by putrefaction only, or the dissolving power of the air hot to 96 gr. equal to the blood's natural heat, the whole mass, but especially the serum, dissolves or melts into a foetid liquor, first the serum, and then the cruor more slowly; till, at length, the whole mass, both of serum and cruor, are turned
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into a volatile and fœtid exhalation, leaving very few fœces behind. When the blood has been once dissolved by putrefaction, there is no artifice can harden or congeal it; as there is none likewise that can resolve it again, after it has been once coagulated by spirits of wine. [The natural gelatinous density and cohesion of the blood is dissolved in malignant and contagious fevers.]

§. 159. Besides these parts of which the blood appears to consist, without subjecting it to any violence, it contains in its substance a quantity of *sea-salt*, which is discernable to the taste, and sometimes visible by the microscope. The fine chalky *earth*, lodged in the blood, is demonstrated from its affording the matter of nutrition and from a chemical analysis, whereby it appears to lodge in the most fluid parts of it, and is more especially intimately combined in great plenty in the oily parts of the blood. Another part in the blood is *air** in an unelastic state, and that in a very considerable quantity; [*to the weight of half a scruple in an ounce*] the existence of which air, in the blood and serum, is proved by their putrefaction and distillation, or by removing the ambient air from them by the pump. But we are not to think from hence, that the blood-globules are bubbles full of air, for they are specifically heavier than the serum, and make no dilatation, by taking off the pressure of the atmosphere from them by the pump. [Lastly, it appears from late experiments, that the caput mortuum or ashes of the blood are repleat, with a sort of iron, which

which the load-stone will attract; and which being found also in the ashes of vegetables, as well as animals, and in most earthy bodies, is, therefore, by some, reckoned an element or constituent principle of bodies.]

R E M A R K.

* The air, as a fixed element in the composition of solid and fluid bodies, has been generally overlooked by philosophers, and even by the chemists, who have, above all sects, gloried in their knowledge of principles or elements; until Mr. Boyle, Sir I. Newton, and more especially Dr. Hales, by many curious and useful experiments, demonstrated, that a great part of the substance of most bodies, in several to half their weight, is a permanent or unelastic air, which being freed [either (1.) *slowly*, by the air-pump, putrefaction, fermentation, distillation, &c. or (2.) *suddenly*, by explosions, fulminations, ebullitions, mixtures, &c.] from the other solid particles, assumes its elasticity, and fills an immense space, in comparison of the body from whence it came. Among other experiments, Dr. Hales found a cubic inch of blood, in distillation, afforded above 30 times its bulk of elastic air; whose particles are, in effect, the wedges of nature, which, depositing their elasticity, pin and cement together the other elements (V. remark ad §. 2.) and particles of bodies for their growth or accretion; and, under other circumstances, regaining their elasticity, serve to break and repel again those parts for the destruction or dissolution of the compound, whose matter may be, by the same instrument, again differently assembled and combined for the forming of other bodies. In general, the nitre contains most air among the fossil salts, which being set suddenly at liberty, by explosion, gives the force of gunpowder; among vegetables,

getables, tartar is half its weight air, above eight gallons in an ounce; and the same proportion of air is there in human calculi, from the gout, kidneys, or gall bladder; next to these, the bones have most, the solids more than the fluids, the crassamentum than the serum, &c. See more of this in the vegetable and hæmastatics of Dr. Hales, which, for their copious, new, curious and useful matter, deserve a place in every Physician's library. Some poisons dispose the permanent air-particles to turn elastic, and separate from the animal juices, with which they are incorporated; whence a wonderful turgescence of the cellular substance and small vessels throughout certain parts, or through the whole habit. And hence, from the stagnant and putrescent juices, may arise emphysematous tumours, and a tympany of the abdomen; how much soever, some surgeons may ridicule the notion and name of those distempers. There is, without doubt, a circulation of fixed air, absorbed by the inhaling vessels of the lungs, alimentary tube, and skin; and the lungs probably exhale again such particles, as regain their elasticity in the blood. For that there often are such elastic parts of air in the blood, especially after drinking flatulent wines, cyder, &c. I am very certain, from the collision and rattling I have often heard them make in the auricles or ventricles of my heart; which I frequently humoured and varied by different gestures of the thorax, and degrees of respiration; and I know not what could become of this air, unless it escaped by the lungs, or was absorbed again as a solid by the blood.

§. 160. Among other bodies, chemistry has various ways endeavoured to show us the nature and principles of the blood; which being
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fresh drawn, and distilled with a slow heat, [gr. 212, or below boiling water] yields a *water* to the quantity of five parts in fix of the whole mass; which water has little or no taste or smell, 'till you come towards the end of the operation, when it is proportionably more charged with a foetid oil, as it draws nearer to a conclusion. (2.) What remains after you have drawn off this water, being exposed to a stronger fire, yields various alkaline liquors; of which the first being acrid, foetid, and of a reddish colour, is usually called the *spirit* of blood; consisting of a volatile salt, with some little oil, dissolved in water, to the amount of one fiftieth part of the whole original mass of blood. (3) A little before and together with the oil, that next ascends in the distillation; a dry *volatile salt* arises and adheres in branchy fleeces to the neck and sides of the glass; and this in but a small proportion, less than an eightieth part of the first mass. (4.) The next liquor is that called *oil* of human blood, which ascends gradually thicker and heavier, at first yellow, and afterwards darker to a black, 'till, at last, it resembles pitch; being very acrid and inflammable, but in a small quantity, about a fiftieth of the whole mass. (5.) What now remains of the blood, in the bottom of the retort, is a spongy inflammable coal or cinder, which being kindled burns away, and leaves ashes behind; which, being dissolved into a lixivium with water, affords a *mixed salt*, partly sea-salt and partly fixed alcaly, leaving a mere dead *earth* in the filter. This fixed salt is scarce
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the five hundredth part of the first mass, and has in itself only one fourth part alkaline: but being urged with the most intense degrees of fire, the whole salt affords some portion of an *acid spirit*; which we judge to arise partly from the sea-salt in the blood, some of which is demonstrable even in the spirit of blood, and partly from the vegetable kind of the aliments, not yet digested into an animal nature. For which last reason, an acid is procurable from the blood of graminivorous animals, as well as from that of man. But the *earth*, separated from the lixivium by filtration, will, perhaps, make about one hundred and fiftieth part of the original mass; and contains some particles which are attracted by the load-stone. The serum only of the blood, by distillation, also affords altogether the same principles; only the water is more abundant, as the oil and earth are in a less proportion.

R E M A R K.

Add to these, another very considerable principle of the blood, even three times the weight of the earth it contains, and, when separated, near 40 times the bulk of the whole mass, [to which add, the elementary æther or fire, §. 2.*] viz. the permanent air, which, as we before observed, (remark to §. 159.) is usually overlooked, because it arises invisibly in the distillation; though, if the vessels are too close luted, or the fire urged too briskly, it will generally make the operator hear, at least, if not feel it, by bursting his glasses. Observe again,

* V. Remark to §. 2, number 2. which never losing its elasticity, as does the air, is the first and great universal agent that actuates the rest of the elements for varying the face of nature.

that

that these are not the natural, but factitious principles of the blood, i. e. to say, they have neither the same forms, nor the same properties, when they are combined together to make blood, as they appear to acquire by an artful separation. We can only say, that such a number and proportion of the more simple or elementary substances of the universe, concur to make the natural elements of the blood, i. e. such as the mechanism of the human body itself forms of the ingested aliments, which are only two, viz. albumen and globules, viz. one an unorganised, colourless, inodorous, and insipid jelly, like the white of an egg, somewhat ropy or filamentary, in proportion to the celerity of the circulation, and differing in tenuity, as it passes through lesser orders of vessels. This makes the immediate matter of growth and nutrition, by sticking to the sides of the least fibres, when it is poured in betwixt them by the least vessels, while the elastic organised globules of the least or smallest class, which make the organic part of the nervous juice, from their greater susceptibility of motion, most likely re-enter the cells or other pores that can send them again into the common circulation. There are then as many kinds or degrees of tenuity in the nutritious albumen of the blood, as there are orders of globules, and smaller vessels to pass through, before the first can adhere as nourishment to the least fibres. The organised or elastic elements of the blood are then necessary in a certain proportion to grind and prepare the other albumen; and are, therefore, to be esteemed a solid permanent part of the body, since they never pass the excretories, but by excess or disease. As for the saline, acid, morbid, bilious, &c. particles, to be found mixed in the current blood, these are rather heterogeneous than elementary parts of it, and restrained to the secretory

vessels only, which send them off to make the excretions and certain few secretions.——As to the particles attracted by the load-stone from the earth of the blood, which may seem so strange to some, 'tis observable, that Sir Theodore Mayerne and Dr. Lister found, that many such particles were always lodged in human calculi, and might be also extracted from the ashes or earthy parts of most plants; whence some have thought the minera of iron a kind of universal element or principle of mixt and text bodies, and, I think, not very injudiciously, since they are more or less diffused through the whole earth and waters, and never touch any salt of what kind soever, but intimately join with them into a vitriol, which is more or less in all springs whatever; and it is notorious, that yellow brewer's-clay, loom, sands, &c. are all tintured by iron; what wonder then if it ascends with the salts of the earth into vegetables, and with them passes into animals, in both which, its particles shall be intrinsically, from their own nature, some of the first that lay the basis of accretions, whether natural or morbid, in animal or vegetable bodies.

§. 161. From the preceding analysis of the blood, it evidently contains a variety of particles, differing in bulk, weight, figure, and tenacity; some watry, others inflammable, and most of them inclined greatly to putrefaction, or to an alkaline corroding state. For the blood, in a sound healthy state, not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid, but mild or gelatinous, and a little saltish to the taste; yet, in some diseases, it is sharp enough, and comes near to a state of putrefaction; as for instance,

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in the scurvy, where it corrodes through its containing vessels, and in those who have an ascites or dropfy, whose waters are often much of an alkaline and corroding nature. But that which is as blood in insects, affords a sharp alkaline calx, effervescing with acids. If human blood be mixed with alcohol or strong mineral acids it runs into a coagulum; but, by the milder vegetable acids, verjuice, vinegar, lime-juice, &c. and also by alkaline salts, fixed or volatile, but especially the last, and by nitre or all neutral salts, it continues or even re-assumes its first fluidity. There is no salt with which the blood makes any effervescence. Violent exercise, too long continued with too great external heat, soon dissolve the blood into a putrid state even within the vessels of a living person.

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We see hence, that too much or too little motion of the blood will, either of them, cause a morbid acrimony, the first in a little time as in fevers; and the last in a longer time, as in cachexies, scurvies, &c. In the fevers, which begin without any dissolving contagion, as well as in too much or long continued hard labour, the blood runs on from the beginning toward the height, through various degrees of inflammatory tenacity, i. e. to say, the more thin and aqueous parts being gradually more thrown out by the fluid secretions, the nutritious albumen or glue in the blood, which forms a sort of crust round the surface of each globule, becomes so thick and tenacious, that they join more strongly together into cohesions, unless kept asunder by motion; but the same degree of motion or impetus will make those globules keep
changing

changing their points of contact longer, which have the greater density, i. e. the red ones; consequently the smaller pellucid globules will, in this case, from their less motive power, and from their greater surface, which augment the attraction of cohesion, first run into filamentary concatenations; for when the attraction of cohesion is increased to a certain degree, their spherical figure will, in all points of contact, be depressed like flattened cakes, and that more or less in various degrees, proportionably to the fewer saline, watry, &c. particles, which interpose and prevent their closest cohesion. This will account both for the production, increase, and degrees of toughness in the pleuritic inflammatory crust of the blood, which is ever an attendant, more or less, upon an accelerated circulation through the whole system, or only some particular part, from pain particularly, provided there is, at the same time, no saline, putrid or dissolving acrimony in the mass. If the arm of a person, who has healthy blood, and no show of this crust, be tied up for some few (10 or 20) minutes, a sort of temporary, but little painful inflammation is produced in that part; the aqueous and the thinner juices are urged into the cellular substance and smaller vessels from the red blood, whence a turgescence of the limb below the ligature, by which the blood, in a degree, confined and stagnant in the veins, will have some of those parts tending to concretion, which retain the least impulse or motion, namely, the pellucid larger surfaced globules, now from stagnating, more thickly incrusted with the cohesive glue; whence, upon extravasation into a cold vessel, they shall be the first that run into cohesion (not with the red globules, for these, having less surface in proportion to their matter, have less cohesion, but) with similar particles, so as to form a white crust, proportionable

tionable to the tenfity of the ligature, and length of time the arm was bound up, provided the vein was opened with a large free orifice; for this feparation or fortment of fimilar cohering parts is begun in the vein, and lodged, as it were, in feveral circular ftrata, moft next the coats of the vefſel, and is then, at length, compleated, when let out into the vefſel; but a ſmall orifice, as it lets out only the quicker moving central thread of the cylinder of blood in the vein, conſiſting of the redder denſer particles, will give little of this cruſt, and of courſe but little relieve the pain; which it occaſions, by lining the ſides of the leaſt arteries with too thick an incruſtation; whence they will be fuller, tenſer and harder, and of courſe more painful. Hence we ſee the uſe and action of nitre, neutrals, ſalts, vegetable acids, and volatile alkalines well diluted, towards removing this phlogiſton of the blood; which, we ſee, is no longer to be found, when the coheſive glue or albumen begins to diſſolve by a return of putrid bile or a putrid alcaliſcent ſtate of the juices in general, brought on by the length and intensity of the fever. You may, in like manner, account for its appearance, when the veſſels are obſtructed in women with child, as from the ligature above. As this phlogiſton lies moſt in the leaſt arteries, and thoſe veins in which the blood moves ſloweſt; therefore, we ſee how cupping, by diſcharging more of it, relieves the pain better than bleeding from a large vein, in which the blood moving faſter contains proportionably leſs of the ſaid inflammatory lentor. Alſo, why bleeding from a large orifice relieves more than from a ſmall one. How a bliſter, by the alkaline diſſolving force of the calx in the blood of the Spaniſh and other ſcarab flies, is ſo uſeful to thin, diſſolve, abſterge, and ſhake off this lentor from the ſides of the leaſt veſſels, where it moſt hesitates:
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for a blister is often of use, by those parts of it which enter the blood and dissolve the juices; when its action, as a stimulus upon the solids, is rather mischievous; and hence bleeding, diluting, clysters, &c. are most necessary companions of it, while, at the same time, that the juices may be supplied with the virtue of the flies, the first blisters must be either dressed with an ointment of them, or a succession of new blisters to other parts be made. But in pleurifies, and other pains from a cold, acid, and ropy viscosity in the least vessels, quite opposite to the phlogiston, blisters have also a double advantage; since there a brisk degree of fever and stimulation of the solids, as well as a dissolution of the viscid lentor, is required. Therefore, in all fevers, where the blood does not tend to a colliquation of its glue and globules, from contagion, bile, pus, or an alcalescent putrefaction, a timely use of blisters and cupping to proper parts will ever turn to good account; if where the pulse is hard, and the blood buff, you bleed and dilute well with nitre and acids; and if with a soft pulse and poor watry blood, you give the bark with nervous and diaphoretic (viz. Julep. Camph. Tinc. Castor. Valer. &c.) medicines after first clearing the passages by a moderate dose of rhab. alone, or with calom. &c. Another advantage will attend an early use of blisters to the feet, as a revulsive of the phlogiston, and of the cold viscid lentor likewise from the pneumatic and sanguificative viscera, no less than as an attenuater of it; whenever you perceive it begin to settle in those organs, where it excites, agreeable to the nature and use of the organ, and degree of its accumulation, those most numerous and troublesome symptoms, by which, without much altering their essence or cure, fevers are largely diversified. 'Tis then evident, (1.) That in all true fevers there is some matter to be

prepared and expelled from the blood by nature, or the conjunct powers of the nervous and vascular system. (2.) That this matter is either a *cold*, viscid, acidish, ropy, and crude matter, as in intermitting, leuco-phlegmatic, flow, nervous, and most hysterical or hip fevers; of which, the fever itself, with blisters, the bark, and nervous corroborants are the cure: or it is of the pleuritic inflammatory kind, which, as a phlogiston, having once taken up its seat in the smaller arteries and veins of some part, multiplies itself, and increases or continues the fever, 'till its action has introduced such a saponaceous, dissolving, or alkaliescent state throughout the juices, as, at length, melts and expels the phlogistic lentor itself; which then, like a well concocted matter, runs off critically by some emunctory. Here, to prevent the colliquation from extending beyond the lentor, even into the firmer globules of the blood itself, small, and often repeated, doses of the vitriolic acids, alum and the bark, have a most certain, and almost miraculous, effect in causing a precipitation of the now subdued matter by the renal, intestinal or cutaneous outlets, and in restoring the lately overstrained vessels immediately to their due action and effects upon the contained fluids. To which practice, I was lead (having the rationale of the thing, and the practice of Dr. Morton on my side) with the most surprising success, wherever it was ordered; and I have now the pleasure of seeing the same practice almost as strongly recommended by Dr. Huxom, from his own ample experience. Only two things you must have a regard to; namely, (1.) To see that your lentor is fully subdued, or that this colliquative state of a fever be actually begun, as you will know by the cessation of pain, softening of the pulse, length and degree of the fever that has preceded, &c. as well as, from the appearance of the
blood

blood itself, which should now be drawn in no greater quantity than will suffice to give us a view of its state. (2.) That your patient have no icteritious or bilious appearance, denoting, that though the lentor be subdued in the other vessels, yet a part of it still lurks, in a manner, almost out of the high road of circulation, in the slow moving vessels and juices of the liver; for here our good medicine will, by coagulating and fixing the lentor, either cause a new fever, or such an insuperable obstruction, as must pave the way to an hundred chronical distempers, which are too frequently to be met with in persons not judiciously cured of fevers.—Even in the third and last kind of febrile matter, which is generally contagious, epidemical or eruptive, a moderate use of the same medicine, to guard the texture of the blood and smaller vessels from the dissolving force of the febrile poison, in the height and declension of the distemper, will be of great use; if you remember at the same time, that this matter, not being superable, like the former, by nature (the characteristic of a poison) must be expelled with a moderate use of the mild diaphoretics.

§. 162. Lastly, by viewing fresh blood in a small glass tube by a microscope, or by inspecting it with the same optical instrument, while it is yet moving in the veins of the living animal, we distinguish its soft, red globules, which are elastic, so as to be able to change and recover their figure, and which, doubtless, make that part called cruor or crassamentum of the blood, mentioned at §. 156. [If it be questioned, whether these are not rather oleaginous lenticular particles, of the same kind with those observed by Lewenhoeck in fish,

and lately discovered in our own species? we confess it is a point difficult to determine; but the ready and frequent division of oil or fat into globules by concussion seems to countenance such an opinion.]

§. 163. Those red globules (§. 162.) we see swimming in a thinner liquor, in which, by the same microscope, we also distinguish lesser yellow globules; and observe, that the red ones dissolve into similar yellow or smaller globules, by rest and warmth. The diameter of the red globules is, by the most accurate experimentors in this way, computed at $\frac{1}{3240}$ of an inch.

§. 164. The pellucid water remaining, in which the former globules were observed to swim, does yet, by the finer microscopes, appear to contain still smaller globules of an aqueous clearness, with various spicula of salts.

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The discovery and consideration of this mechanism of blood, whereby we see it, in great part, consists of elastic, organic, round machinule of various densities and diameters, which, by their greater mobility from one common impulse, grind and attenuate the other viscid nutritious and filamentary orropy parts of the blood, is of the last importance towards understanding the nature, action, and cure of fevers, poisons, and most disorders springing principally from a vitiated state of this general source, from which all the other animal juices are supplied. We observe, that sugar boiling in a syrup at the bakers, in some measure resembles the blood, as a soft or solid body, (re-

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mark to §. 1.) kept by the violence in a state of fluidity. This, when its watry parts are exhaled enough to give the sugar so great a heat as to extricate and expel part of the included permanent air in the shape of elastic vesicles or bubbles, (remark to §. 159.) it swells to such a degree from the said air confined by the tenacity or cohesion of its parts, that the whole would soon be thrown out of the copper, if it were left to itself. But to prevent this, a spoonful of butter or oil thrown in, diffuses itself so throughout the whole mass, that, by lessening the contact and cohesion of the particles, the confined air readily escapes as from water, and the swelling or turgescence immediately subsides. Much in the same manner, certain vegetable, animal and contagious poisons shall, upon entering the mass of blood, diffuse and dissolve that healthy degree of cohesion in the parts which is necessary to make and keep it an organic fluid, that it shall, in a little time, turn from a mild albuminous to a corroding gangrænous incoherent mass, dissolving not only the globular texture, but also the pulpy fine vascular fabric in the encephalon, almost as soon as it can extend thither. Thus, among the vegetable tribe, act the laurel-water, circuta-aquatica, the great purple-flowered wolf's-bane, deadly-night shade, hen-bane, nux vomica, roots of hemlock-drop wort, (and even opium itself in a large dose); only, as these are commonly taken into the stomach, they begin the tragedy first in that part, which, from its sensibility and nervous consent, excites many symptoms not seen in other poisons. Thus act the epidemical, contagious and pestilential poisons, with those of the snake kind. In how few hours the pestilential poison will often kill, and melt not only the blood, but even the liver, spleen, lungs, and other viscera into a gangrænous incoherent mass, those
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are not ignorant, who have read the writers on the plague. And how soon the rattle-snake poison will have the same effect, may appear from the late creditable relation, which father Feuill gives us in his journal of physico-mathematical observations made in New Spain, of a Dutch physician at Lima, who being herbalizing in a wood, and hearing a young Indian woman cry out from the bite of a rattle-snake, immediately ran to her assistance; but well knowing the fatality of the poison, sent one to call the parish-priest to give her confession and communion; but before he could arrive she died, and changed so much in a few hours, that, in lifting her body, the flesh, like a pulp, came off as if it had been corrupted, which obliged them to put the body in a cloth to carry it to the church. What a colliquative strength the least quantity of this poison has, may be seen from the terrible course Mr. Briental went through at Philadelphia, (Phil. transf. n^o. 478.) who, by the precaution of sucking his wound and spitting out the poison, (which benumbed his tongue and lips) making a ligature to confine what remained in the arm, and a copious discharge by scarifying his hand, and flitting the skin of his fingers, was lucky enough to escape with life, after lying ill nine days; though the hand and arm continued all the summer spotted like the snake. Nor is the gangrænous dissolution and acrimony, which the blood often acquires by slow degrees in the scurvy, much less wonderful; by which, in the account of Lord Anson's voyage, it melted and eat through the tough callusses of bones and hard scars of old wounds, so as to make them bleed afresh. But let us return from the diseased, to the natural and healthy state of the blood.

§. 165. From the preceding experiments compared together, arises that knowledge which

which we, at present, have of the blood; namely, that the crassamentum or cruor is composed of globules, which being forced together by the coagulating causes, (§. 156.) which increase their attraction of cohesion, harden into a confused solid mass. The inflammable or combustible nature of the said globules is proved from dried blood, which takes flame and burns; as also from the phosphorus, or rather pyrophorus, (since it not only shines, but generates combustible fire) which is distilled from human blood; and from these probably arises the greater part of the pitchy oil that is obtained from blood by the violence of fire, §. 160. (4.) But actual filaments, there are none naturally in the blood; though they may be made in it, by the addition of cold water.

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The attraction of cohesion in particles being as their contiguous surfaces and tenacity of the incrusting fluid, the yellow and lesser globules will cohere together more powerfully than the red ones, as well from their greater surface and contacts, as because moving slower in the blood, a more viscid and thick glue adheres to them; whence by cold or intense heat, or a diminution of the interposed water, these first run into strong filamentary chains every way, like a sponge made of spider's threads, betwixt which the larger red globules are locked up or intercepted; and by washing them out with water, from a cake of fresh sound blood, you have the filamentary part compacted together like a fibrous flesh. And as these less globules thus more strongly attract each other, than they are attracted,
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either by water or by the red globules ; therefore, upon stirring round a mass of blood with your finger, &c. before it is congealed, instead of shooting every way like the threads of a sponge through the whole mass, so as to give it a kind of solidity, they will be wound up into a bottom of a compact fibrous consistence, leaving the remainder a purple uncongealing fluid, chiefly of water and the red globules, &c. Much in the same manner, we see in chemistry, that spiritus salis ammoniaci (cum sale tartori preparatus, which is still no more than a salt dissolved in water) & alcohol vini being mixed, the salt immediately shoots every way like a lump of sugar, while the water and alcohol combined, are locked up in the cells or interstices.

§. 166. The yellow serum of the blood appears likewise to consist of lesser globules swimming in water ; and is what we described before at §. 157. In the watry or thinner liquor of the serum, whose particles are not visible to the eye, there are contained the same principles, with a portion of water, as was shown in the blood itself, §. 160. of which the force of fire makes alkaline salts. In proof of this, we may alledge a distillation of the saliva or mucus with the nature of the perspiring matter of Sanctorius.

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The saline and oily parts of the serum, as well as the blood, are in a healthy state, neither acid nor alkaline, but neutral, of a peculiar kind, coming betwixt nitre, sea salt and sal ammoniac ; whence healthy serum, though brackish to the taste, gives no pain to a wound, to the eyes, nose, or to
other

other sensitive organs, where even water alone will prove a stimulus: but those few volatile alkaline salts and oils, which come into the blood from the aliments or medicines, or which are made by the vital heat and attrition, exhale chiefly by the perspiration; which, obstructed, causes a retention of that matter, which, if retained in a considerable degree, will stimulate the heart and arteries into a fever, and tend to dissolve the blood into a putrid mass, if left to itself. The same perspirable oily and saline parts, in a more exalted, putrid, and caustic state, of which it is capable of various degrees, becomes the matter which propagates contagious fevers of all kinds; being in itself an animal ferment, that disposes the airy, oily, and saline parts of the blood to separate by a putrefactive or intestine motion in the least vessels, where the progressive motion is slowest, so as to put on an acrid disposition similar to that of itself: but the chemical volatile salts and oils of blood and serum, as well as of other animal substances, are not the natural, but factitious principles of them made by force of fire.

§. 167. The exact mass or quantity of blood, contained in the whole body, cannot be certainly computed. Yet we know, in general, that the mass of humours is much greater than that of the solids; only we are to consider, that many of them do not flow currently in the circulation, as the glue or jelly that lodges in most parts, and the fat. But if we may be allowed to form a judgment from those profuse hæmorrhages, that have been sustained without destroying the life of the patient, with experiments made on living animals, by drawing
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out all their blood, joined with the bulk of the arteries and veins themselves; from these principles, the mass of circulating humours will be at least fifty pounds; whereof near a fifth part will be true red blood, current in the arteries and veins; of which the arteries contain only one fifth, and the veins the other four.

§. 168. Nor does the blood always contain the same, or a like proportion of those elements or principles, which we have before described in it: for an increased celerity, whether by laborious and strong exercises and a full age, (from 30 to 40) fever or otherwise augments the crassamentum with the redness, congealing force and cohesion of particles; and the hardness and weight of the concreted serum with the alkaline principles are, by the same means, increased, §. 144. On the other hand, the serum and the mucus it contains are increased by the contrary causes, the more as the animal is younger, less active or exercised, and fed more on a watry vegetable diet, by all which the crassamentum of the blood is lessened, and its watry part increased. Old age again lessens the crassamentum, and the gelatinous part likewise.

§. 169. From these principles, (§. 136 to 139.) but with a conjunct consideration of the solid fibres and vessels,* the different temperaments, and morbid constitutions of people are derived. For a *plethoric* or *sanguine* habit arises from an abundance of the red globules; a *phlegmatic* temperature is from a redundancy of the watry parts of the blood; a *choleric* disposition

of the humours seems to arise from a greater acrimony and alcalescence of the blood, as appears from those who live on flesh and on the human species, being so much fiercer and more passionate than those who live on plants or on vegetable food. As for the *melancholly*, if there is really such a humour in the blood, it seems to consist in a redundancy of the earthy principle, §. 169. [With respect to the solid parts, a greater firmness joined with as more exquisite sensibility or nervous irritability, disposes to a choleric habit; and a less irritability with a moderate density, to a sanguine habit; and a lesser degree both of density and irritability are to be referred to a phlegmatic temperament. In the melancholly again, a weakness of the solids is joined with the highest degree of nervous irritation or sensibility.] But you must be careful not to make these temperaments as the sole and limited systems or classes of constitutions; which, in the course of nature, are found to be not only four, eight, or even thirty-two; but are really distinct in numberless degrees.

R E M A R K.

* 'Tis a wise caution of our author not to make any deductions physiological or therapeutical, unless the conjunct state of the solids enters the consideration. The quantity or quality of the blood vitiated or offending are not the primary causes of slow diseases, but the effects of a vitiated state of the solids, and their actions, by which the blood and all other juices are moulded or composed, and to the state of which their quantity and quality are answerable; and, for this reason, all
good

good professors have proposed the consideration of the elastic moving fibres and vessels, as the necessary ground-work or foundation to a knowledge and cure of diseases.

§. 170. The red parts of the blood seem chiefly of use to generate heat, since they always abound in proportion to the natural heat of the animal. These being confined by the largeness of the globules, within the red and first order of vessels, hinders the collapſion of their extremities; and in receiving the common motion of the heart, by the greater density of their parts, they hold the motion longer, or make a greater impetus and attrition upon the lesser orders of humours, upon which their motion is impressed. And hence it is, that the red part of the blood, being too much diminished by profuse bleedings, there follows a stagnation or lessened motion of the humours in the smaller vessels, whence fatness, coldness, dropſy, &c. By the same rule also, a due proportion of the said red blood is necessary within the habit, to generate and repair new blood for the uses of the whole system. For, by large hæmorrhages, we see the blood loses its red or dense nature, and degenerates into a pale, ferous or watry state.

§. 171. The hardening serum (§. 157.) is more especially designed for the secretions and nutritions of the parts, as will be hereafter more apparent (§. 239 to 243.) The thinner juices thence secreted have various purposes, as the dissolution of the aliments, the moistening of the external surface of the body, and surfaces
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of the internal cavities, to preserve the flexibility of the solids, and conduce to the motion of the nerves, the sight, &c.

§. 172. Therefore health cannot subsist without a dense and red blood, whose quantity too much diminished causes a stagnation or slow rosy trailing of the juices within the smaller vessels; whence cachexy or paleness, coldness, weakness, and the like. Nor, on the other hand, can life or its proper offices be carried on, or health subsist without a sufficiency of thinner juices intermixed with the red blood; which, being deprived of its watry part, congeals and obstructs the smallest passages of the vessels, and kindles too great a heat.

§. 173. If it is asked, whether there be any difference betwixt the arterial and venal blood? we answer, that some difference there seems to be; the former, having lately passed the action of the lungs. But, in experiments, I scarce find any observable difference either in colour, density, or any other known diversity. For the circulation is very quick, and the venal blood itself was but a little before arterial. [However, the arterial blood is apparently of a more bright or splendid red; and having a greater degree of fluidity and proportion of watry parts, may so far differ from the venal darker coloured blood. But, in this respect, it remains that we make further experiments.]

§. 174. From one and the same mass of blood, driven into the aorta, are generated all the juices or humours of the human body,

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which;

which, from their affinity one to another, are reducible to certain classes following; but the manner or artifice, by which each of them are separated, ought to be accounted for by the fabric or mechanism of the glands themselves.

R E M A R K.

As the blood runs quicker, and into commixture in the veins, as it comes nearer the heart, so its particles move more slowly towards a separation in the arteries, as they get farther from the heart, with a diminished impulse. Thus the motion of the blood in the arterial and venal vessels may be, in general, compared to a body ascending perpendicularly, contrary to the force of gravity, by some impulse, and with a momentum or celerity continually lessening; and then returning or descending with a celerity perpetually increasing: only, in the blood, this retardation and acceleration are neither made uniformly, nor in any certain or regular proportion, with respect to the distances from the heart; because the diversity of strength, ramification, convolution, &c. of the vessels themselves, in which it moves, are irregular and unlimited.



LECTURE VIII.

Of the secretions.

§. 175. **T**HE classes or tribes of humours, which, being deposited or strained off from the blood into other vessels, are said to be *secerned or secreted*, seem reducible to four; of which the *first* includes all the viscid and lymphatic juices, which, by fire or alcohol vini, turn into a hard coagulum; although generally in the living animal, they are capable of flying off in form of a vapour, and after death are within the same vessels compacted into a gelatinous thickness. To this class belong the vaporous juices of the ventricles of the brain of the pericardium, pleura, peritoneum, vaginal tunic of the testicle, of the amnios, joints, and probably of the womb, with the juice of the stomach and intestines, of the renal capsules, and lastly, the lymph itself, commonly known and called by that name.

§. 176. The *second class* is of those juices, which are some of them exhalable, like the former (§. 175.), but being more simple and aqueous, are neither to be coagulated by fire, nor by rectified spirits of wine; and others of which do not exhale, but, being deposited in their respective excretory ducts, are expelled by some common outlet, proper to a part of some gland. To the former of this class belong the perspirable matter of Sanctorius, and

probably the internal perspirable matter of the epithelium and cellular substance, with part of the tears and watry humours of the eyes. To the latter of this class belong the remaining part of the tears, the saliva and pancreatic juice, that of the renal capsules, and the urine. The sweat seems to be a mixture of the perspirable matter and the subcutaneous oil.

§. 177. The *third class*, differing from both the preceding, includes the viscid, sluggish or ropy juices; but such as are of a watry disposition, and not congealable into a jelly, but hardening into a crust-like or scaly substance, by exhaling their water. Of this sort are all the kinds of *mucus* in the human body, spread through all the internal passages for air, aliments or urine; the cavities of the genital parts, liquor of the prostates and seed, to which add the black humour of the uvea in the eye.

§. 178. The *fourth and last class* is that of the inflammable juices, which, at their first formation, are indeed thin and watry, but, by time, stagnating and exhaling their more watry parts, become a thick, oily, inflammable liniment, often very bitter. To this class we refer the bile, ear-wax, sebaceous and oily liniment of the skin, the marrow in the bones, and all the fat of whatever consistence, or in whatever part seated throughout the human body. And the milk itself, so far as it is butyraceous and inflammable, belongs to this class.

§. 179. Those

§. 179. Those who consider, that in the blood are found a coagulating serum (§. 156.), an exhaling water (§. 160.), a sort of viscid mucus (§. 156.), and lastly, a thick and thin oil (§. 160.), may thence begin to perceive the possibility of a separation to be made from the blood of all the foregoing classes (§. 175 to 179.) of humours; in as much as we thus see their constituent principles are already in the mass of blood itself. But in what manner it is brought about, that oil is separated from the blood in one part, a watry liquor in another, or a gummy mucus in a third, is a task that still remains to be explained, and requires a previous description of the secretory organs themselves.

§. 180. The albuminous or hardening juices are separated almost every where from the arteries themselves, into continuous excretory canals, without any intermediate organ or machine betwixt them. The proof of this we have from injections of fish-glue, water, and thin oils, which very readily pass the red arteries, and are poured out like unto sweat into all the cavities of the body (§. 155.), in which we naturally find the said serous vapours in form of a coagulable water; nor do the injections in this course meet with any intermediate knots, or stops from any hollow cavities and cells. Finally, the blood itself, being so readily poured out into most of these cavities, without any permanent damage, when its course is either much obstructed, retarded or urged with a greater impetus through the arteries,

shows plainly that there is a short and open way betwixt the red blood vessels and those excretory ducts; [whence the yellow serum differs not much from the cruor.]

§. 181. Among these juices we reckon the venal lymph, mentioned (§. 51.) before, which passes through the valvular pellucid vessels to the thoracic duct. For this seems to be drawn off immediately from the arteries, if we give any credit to the numerous experiments of great anatomists, which show that red blood, mercury and other liquors pass from the sanguineous arteries directly into the valvular lymphatic veins themselves. The credit, both of this fact and the experiments, is also further confirmed by the mixture of redness and yellowness, often observable in the lymph itself; and which, by the microscope, is a demonstration of the red sanguineous and yellow serous globules, which pass and float in the lymph, §. 161. and seq.

§. 182. It must not indeed be denied, that these lymphatic vessels have a sort of peculiar glands to themselves, into which the said lymphatics deposite their contained juice, and then convey it away from them again. But then the lymphatic vessels do not arise in these glands, with which they only communicate in their passage. For they arise visibly enough upon the surface of the lungs, liver and intestines, and run on for a considerable length before they enter those glands.

§. 183. These glands then seem to contribute something peculiar to the lymph and chyle
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in their course, more than has hitherto been well discovered. The structure of them here follows. They appear, as they are called, *conglobate*, or of an oblong, olive-like figure, sometimes solitary, but often in clusters, and loosely wrapped up in the cellular substance, in which they enjoy a sort of free liberty or floating motion, in most of the internal parts of the human body, and in many of the external parts. Among the latter we may reckon those which, arising in the face and upper part of the parotid gland, and angle of the lower jaw, descend along the side of the neck with the jugular vein; from thence dividing as it were, or receiving troops from the arm, they pass on in a direct course with the subclavian vein to the arm-pit, where they are most numerous. Some again are extended as far as the flexure of the elbow or cubitus itself; but none appear on the rest of the upper limb, nor upon all the back.

§. 184. In the thorax they descend in great numbers with the wind-pipe, and along the sides of the pericardium; others descend upon the anterior face of the vena cava and pericardium down to the diaphragm. Posterior lymphatics there are many, encompassing the wind-pipe on all sides, and playing round its ramifications, reach to the extremities of the lungs; while those in the posterior mediastinum ride over the pericardium, and with the thoracic duct extend to the diaphragm.

§. 185. In the abdomen lastly, there are others called the lumbal lymphatics, which

form a considerable troop in the folding of the groin, from whence extending along with the great blood-vessels in the course of the Sartorius muscles, they vanish in the ham or bending of the knee. Other lymphatics pass from this inguinal troop into the pelvis, and continue their course upwards through the cellular substance, behind the rectum, and along with the large hypogastric blood-vessels. There are also small lymphatic glands of the same kind, with their respective troops, seated in the greater and lesser curvature of the stomach, at the origin of the great and little omentum, at the entrance of the porta into the liver, in the course of the splenic blood-vessels near the spleen, and lastly, through the whole extent of the mesentery and mesocolon.

§. 186. The common fabric of these lymphatic glandules is, that they all consist of a strong, external, smooth membrane, painted with many red blood-vessels; within which is a soft and lax cellular substance, but of a short extent, betwixt the cells of which run numberless small blood and lymphatic vessels. As for any folliculus or concavity, muscular fibres, or duplicate membranes, they are to me unknown.

§. 187. That these glandules are of some use to the lymph and lymphatic vessels, is certain enough; because we see no lacteal or lymphatic vessel ever reaches to its insertion, without first distributing its branches through one of these glands, and receiving reductory branches from thence. The chylous juice,
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with which these glandules are filled in children and other young animals, and the ink-like juice which they contain in the breasts of old people, proves that there is something separated from the blood in these glands, and poured into the lymph and chyle, which are here probably expelled into the cellular spaces of the gland. Their greater magnitude and more perfect structure in the younger animals, with the shrinking and corruption or destruction of them in adults and old people, persuade us, that this their secretion is more perfectly made in the younger animals, and that it perishes in the older. And no part is oftener scirrhous than these; whence it is not probable, that the lymph is in them accelerated. The thymus is of the conglobate kind of these glandules, but divided into lobules; but there are found also in the groins, arm-pits, and other parts, conglobate glandules of this sort, collected into clusters.

§. 188. Another coagulating juice, which hardens likewise by mineral acids and alcohol, is the albumenous humour of the joints, which mixed with some fat and medullary oil, makes a most soft or smooth liniment, to lubricate the heads of the bones and lessen the friction of the joints. For the separation of this liniment, certain conglomerate glandules of a peculiar fabric are assigned, which are usually so placed in the rough sinuosities of the joints, that they suffer a moderate compressure, increasing their discharge, without bruising, by the motion.

§. 189. These

§. 189. These mucilaginous glandules have a peculiar fabric. The larger of them rest upon the bones with a broad basis, from whence they are gradually extenuated or acuminate into a ridge, from the thinnest margin in which they deposite their juice by open ducts. They have a good deal of fat intermixed, and are manifestly composed of lesser bunches. Others still smaller are scattered about the vaginal capsules of the tendons, and betwixt the dividing fibres of the tendons, which last seem to be almost of the nature of simple glandules, turgid with a yellow mucous serum.

§. 190. The uncoagulable juices of the first sort (§. 176.) are secreted in the same manner with those which harden (§. 175.), to wit, from the exhaling arteries, which arise from the red sanguineous arteries, without any intermediate follicle or cavity betwixt them. Thus the vessels, which pour out the perspirable matter through the skin and lacrymal ducts of the first sort, suffer a watry or thin gluey injection to transude so readily from the arteries, as leaves no room to doubt of this truth. [And these secretory ducts have also a considerable degree of irritability; whence, by any stimulus or contact of acrid particles, they discharge more juice in a given time, than what they distil in a state of health.]

§. 191. But in the latter salival kind of that class, the secretion is made by means of conglomerate glandules, which the ancients so called from their cluster-like fabric, and esteemed them almost the only proper glands. These

are composed of roundish lobules or clusters (somewhat like those in bunches of grapes, currants, berberies, &c.) loosely conjoined together into larger masses by the yielding cellular substance, which, at last, often forms a denser coat or covering to the whole, like as we see in the parotid and maxillary glandules. Through the intervals, betwixt these glandular clusters or grape-like bunches, run the arteries and veins, which are here large or considerable enough. But most of the conglomerate glandules separate their juices in such a manner from the blood, and from thence, discharge it so, that each grape-like portion sends out an excretory duct, which, joining with others of the same kind, form larger trunks, which, at last, in the manner of a vein, end in one canal, which conveys the humour, separated by the gland, to the part for which it is designed, as the cavity of the mouth, intestines, surface of the eyes, &c. There are, indeed, some of these glands in which the said excretory ducts are either not present, or, at least, not yet discovered; as we observe in the thyreoidal glandules, those called *capsulæ renales*, the thymus, and the pituitary glandules.

§. 192. The *acini* or kernels of these conglomerate glands are each of them circumscribed and limited by a harder stratum of the cellular substance; by which substance they are also subdivided into lesser acinuli, as is evident to the eye, and by the microscope. But it may be questioned, how does this subdivision end? whether or no is every simple acinus or kernel hollow

hollow in its middle, that, by receiving the humour transuding from the arteries into the follicle or cell, it may be sent out thence by the excretory duct? whether or no are we persuaded to believe such a fabric obtains from the small shot-like stones and hydatides bred in these glands, with the round scirrhi that sometimes fill the kidneys? whether is this opinion made probable by the morbid round concretions formed in the liver, spleen, kidneys, testicles, and cortex of the brain? or from the bunch-like division or appearance, which those viscera have in younger animals? [whether the cellular substance, that surrounds the extreme vascules in all parts, does not communicate by open areolæ or cells, in which a secreted humour is poured by these glandules?]

§. 193. In short, none of these arguments appear true or conclusive. For the acini, which are found in the viscera of brute animals, are component lobules, and not elementary parts; but are large and compounded, for the convenience of each beast. The morbid concretions are almost all of them a sort of placentulæ formed in the loculi of the cellular substance, and take up their seat even in the limbs themselves, where there is not the least room to suspect any thing of a glandular fabric; and are composed, as to their matter, of oil, earth and vaporous particles, extravasated into some of the least interstices of the cellular substance, where, stagnating and compressing the adjacent follicles, they form to themselves proper membranous tunics. On the contrary, the watry
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and fluid nature of the juice, secreted in these glands (§. 176.), are arguments that it meets with no arrestment in the separation, nor places of stagnation in its way. For all the juices, which rest any time in the warm cavities of the human body, which are full of absorbing vessels, are each of them more or less inspissated, and approach either towards a mucous or an oily disposition. Moreover, if there were any such arrestments, anatomical injections would meet with more difficulty in passing from the arteries into the excretory ducts of those glands; which, under such circumstances, would be impervious to thick injections, and thin ones they would exhale into their cellular fabric. Yet we see that the superlative art of great anatomists has not only conveyed injections, but even thick ones like wax, directly from the arteries of the salival glands, liver, &c. into their excretory ducts, and this without filling up any intermediate knot-like cavities, which, according to the foregoing hypothesis (§. 192.), they ought to exhibit.

§. 194. Therefore the *acini* or kernels of these glandules appear composed merely of arteries and veins (which last include excretory ducts) divided and subdivided, parted and connected by the intervention of a good deal of cellular substance, whose strata growing gradually more compact or firm as they enlarge, at length show their contents moulded into a sort of globular nut-like figure. In the belief of this, we are confirmed by analogy in the lobes of the lungs, the lobules of the thymus, and
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from the structure of insects, but more especially the fabric of the testicle, in which we plainly see, that lobules are formed of excretory ducts, connected together in fasciculi by a very soft cellular membrane. [But they seem not to pour their juices into a cellular fabric, which would intercept or make difficult the passage to an excretory duct.]

§. 195. Thin watry juices, neither coagulable nor wholly evaporating, are likewise in other parts generated without the assistance of conglomerate or kernelly glandules. For thus the urine is deposited from the red or sanguineous arteries into membranous pipes, with which they are manifestly continuous, and form an easy way, admitting air, water, and mercury to pass in like manner. And after the same manner, though less evidently, the nervous juice seems to be separated in the brain.

§. 196. The third class, or *mucous* juices (§. 177.) are indeed almost every where separated into, and discharged from sinusses or hollow glands. These true glands or follicles have, in general, such a fabric as makes up an ample cavity, every way circumscribed by a membrane; but in such a manner, that the flesh itself of the part, to which the gland adheres, is often taken for another close hemisphere of the follicle. The said cavity or follicle is for the generality round, but sometimes it is oblong, and obliquely creeping betwixt the adjacent parts; as for example, in the urethra of the male, and in the follicles of the sinus muliebris.

§. 197. Into

§. 197. Into these follicles or cells the least arteries (or the vascular flesh surrounding each crypta or cell, and compleating its convexity) open by producted extremities within the cavity of each crypta, into which they distil or exhale their respective juice, where, being retained from the narrowness of the excretory duct, the more watry parts are drawn up by the absorbing veins, which correspond to, and resemble the exhaling arteries; and thus the follicular or cryptal juices receive a considerable degree of thickness. The truth of this we are taught from the structure of the simple follicles, observable in the tongue, in which both the importing arterial ducts or pores, and likewise the excretory mouth, are visible to the eye; and from the velvet-like tubuli lining the stomach of birds, quadrupedes and mankind, in each of which an importing small artery, a reductory vein, and an excretory canal, appears to open pendulous in the cavity; and lastly, from injections, which discharge a colourless wax into the simple glands.

§. 198. Whether the mucous cavity of such a glandule be long or round, it has always an excretory duct, which, for the most part, is none of the least; although, in the round mucous glandules, the discharging duct or orifice be less, in respect to the reserving cavity, than in others. This discharging orifice often opens into the common large cavity, into which the mucus is to be poured, without any intermediate duct; for thus it is in the back of the tongue, and in the simple glands of the stomach and
intestines,

intestines, where they have been denominated *cryptæ* or cells by Ruysch. The sinusses have often the like fabric, opening without an intervening duct, as in the urethra of the male.

§. 199. Another kind of these mucous glands are those, which we commonly call *conglutinated*; where many simple follicles are folded up together in one common covering, and open with their gaping orifices into one common sinus, without forming any true excretory duct. This fabric we observe in the tonsils.

§. 200. Other simple glands of this class have an *excretory duct*, by which they expel their mucus, namely, a narrow, membranous, cylindric, small vessel, opening with its posterior orifice into the cavity of the glandule, and with its anterior orifice into the common cavity, for which its mucus is designed. These excretory ducts are of considerable length in the subcutaneous and sebaceous glands, and in those of the palate and wind-pipe. In some parts also, the pore or orifice, and its duct, are more easily demonstrable, than the follicle or body of the gland itself; as in the nostrils, larynx, rectum, &c.

§. 201. In others again, an assemblage of these ducts, arising each from its respective follicle, run together into one like the branches of a vein, so as to form a considerable excretory canal, common to a number of follicles. To this kind belong the compound mucous glands of the intestines, some of the larger in the cavity of the urethra, with the blind or impervious duct or sinus at the root of the tongue,

tongue, to which, in brutes and birds, add the fringe-like tubuli of the stomach. The glands of this sort may be called *simple ones compounded or continuous*; but where they lie only contiguous one to another, they may be called *simple aggregate* or congregated glandules; as are those of the fauces, stomach, intestines, &c.

§. 202. The inflammable juices (§. 178.) are separated by organs differing in their fabric. The fat and marrow are deposited, without the intervention of glands, from the small mouths of the least arteries into the cellular coat or rather substance; and the same fat again escapes from under the skin by small pores or ducts, without the assistance of any glandular follicles. But the ear-wax, and the waxen or sewety liniment of the skin, are separated by glands of divers kinds. Most of the sebaceous glandules are visible enough, with an open or naked mouth in the skin, that leads immediately into the follicle, without any duct of considerable length; as we see in the external ears, nose, rings about the nipples, in the female nymphæ, and the valley or groove that runs betwixt them and the external labia, in the clitoris and in the male glans and præpuce. These differ but little from the cryptæ (§. 187.) except in their contained matter, which they separate.

§. 203. There are others of the sebaceous glands, which have an excretory duct of a considerable length, like most of those in the skin, which, being seated in the cellular substance, have consequently a duct long enough

to perforate the skin. Thus we see it is in the face more evidently, where the length of the duct is often to be measured by the con-creted maggot-like substance pressed out; the bulk of which demonstrates, that a follicle or cell lies under the narrower pore.

§. 204. There are still other sebaceous glands of the continous or conglomerate kind (§. 201.) in which many cryptæ by small ducts meet together in one larger excretory duct. Thus in the face, in several places, there are large pores in common to a number of subjacent cryptæ. And of this kind are those sebaceous sinks or little intestines in the eye-lids: and thus it is in the organ which separates the sebaceous perfume in the sebaceous glandules of the musk-goat of America.

§. 205. The milk, being a humour of its own particular kind, formed of oil and watry juices intermixed, is separated by conglomerated glandules, whose fabric we described at §. 191. Whether the secretion of the bile be glandular, is controverted; but there are many arguments to persuade us, that the liver is a mere vascular fabric, whence the bile distils immediately from the extremities of the porta into the *pori biliarii* or roots of the biliary ducts, without passing any cells or follicles by the way; and in this we are more especially confirmed by the Ruyfchian art of injection, in which the wax passes directly from the porta into the biliary ducts, without exhibiting any intermediate knots or stoppages; and therefore we see the milk and bile are both of them much
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thinner and more watry than the fat, or the sebaceous matter, which thicken in follicles.

§. 206. It now remains for us to enquire, how from one common mass of the blood, the same variety of peculiar juices are constantly separated, each in their respective places; so that we never see milk secreted in the kidneys, bile in the thymus, or mucus in the sebaceous glandules. This problem, indeed, may be solved by one, who shall have previously acquired a thorough knowledge of the intrinsic fabric, that obtains in each secretory organ. In the mean time, we shall here propose what has been hitherto advanced with certainty on that subject from any known principles, whose truth we are convinced of.

§. 207. And first, the blood itself, from whence the humour is to be secreted, undergoes a sort of hydraulic preparation in the various parts, by which it puts on such a character or disposition there peculiar to itself, that more particles of a like nature with the humour abound in that blood, which *nature* intends to separate from it. In the liver, the venal blood arrives with a very slow motion, full of oil, and full of the semiputrid vapours of the intestines. At the testicles, the blood is brought slowly through very long slender and inflected canals, arising at very small angles, and passing out of the abdomen through a cold tract under the skin. In the carotids, it is probable that the denser parts of the blood ascend, while whatever is more watry descends into the abdomen and to the kidneys; also to

the forming of the salival juice of the pancreas, liquor of the stomach and intestines.

§. 208. Another preparation of the blood towards secretion, is from its retardation in the least vessels: whereby the red and denser parts go on by themselves along the axis of the canal, while the other lighter and more sluggish, or viscid and less moving particles, recede to the lateral opening or branches, so as to enter the secretory orifices, which pass out from the sides of the said vessels.

§. 209. The *lights* of these lateral or secretory orifices, though of different diameters in different parts, are yet always small enough, in their healthy and natural state, to refuse the red blood. Hence, therefore, we may conclude, that, being enlarged by an increased force of the heart, they every where admit a good deal of the red blood from the sanguineous artery, which they arise from, and open into; being in their natural state not much less than the red globules. And hence the same secretory orifices or ducts, which refuse thick injections of wax or sewet, do, nevertheless, generally admit thinner liquors injected into the arteries. Therefore this is the first and most simple mechanism, or machine of secretion; viz. that the light or opening of the excretory duct may admit only such particles as have their greatest diameter less than the diameter of the said opening. From this reason only, it is, that the yellow arteries convey off a pure liquor from the blood, and that the uriniferous ducts exclude both the red blood and coagulable serum.

serum. [But this is not the sole cause, since the same juices are generated by large as by small animals.]

§. 210. Merely by this law, (of the discerning orifices) the secreted juices may be of many different sorts: for those, whose lights or tranverse sections are the least, will receive only the thinnest juices, as in the small vessels of the brain; and the larger ducts will admit water and jelly, while the thickest fat will enter the biggest of all. Moreover, if a number of secretory organs are formed in a succession from one discerning artery, each of them having large mouths or ducts; in that case, the last, which come out from the said artery, will receive only the thinnest juices. But if those, which are first formed in order from the discerning artery, have smaller ducts, then the last only will receive the grossest juices.

§. 211. From hence it is, that the secretions, which are generally made immediately from sanguineous arteries, without passing the serous lateral ones, (§. 44.) are all of gross juices, thick, coagulable or watry; as the fat, urine, juice of the stomach and intestines, &c. But the other thinner juices are (3.) secreted not from sanguineous, but from smaller pellucid arteries arising from the former. To the discerning mouths, therefore, of these last not only no red blood, but no serum, fat or other gross juices can have admittance. Thus the more thin and pure humours are separated of consequence; as for example, in the eyes, cortex of the brain, &c.

§. 212. Some share of the secretion ought, perhaps, to be allowed (4.) *to the angle*, which the secretory branch intercepts with its trunk. For it is easily demonstrated, that at right and retrograde angles, only the viscid and sluggish juices are expelled by the stronger force of the denser particles, which hold on their course along the middle of the artery; whilst the denser go off at half right angles. For those who have made the truest observations on living animals, have seen, that the velocity of the blood is greatest in vessels of the acute angles, and less in those of right angles. That the effect of these angles in the vessels is considerable, with regard to the secretion, we are persuaded from the structure of them in several parts of the body, since they form different angles in different parts, with respect to their trunks; and in some parts compose net-works. For the small vessels, in general, resemble the branchings of little trees or shrubs, the trunks and arms of them every way sending out smaller branches, but in different angles; at small angles, for instance, in the large intestines, and at larger angles in the smaller intestines. Thus in the spleen, the small red arteries arise so thick from their trunks, that they resemble a wisk or sprinkler; in the intestines, they resemble pencil brushes, vermicular arches in the kidneys, stars in the liver, a radiated circle in the uvea, and in the testicle, a lock of hair curled up into a button. But we deservedly receive it as a rule, that the creator never made
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this diversity of fabric, without its proper use and effects.

§. 213. And (5.) the *inflexions* of the smaller vessels greatly retard the motion of the blood, in which, therefore, the greater part of the force received from the heart, is evidently spent in changing the figure of the vessels. The repeated inflexions, therefore, of the secretory arteries increase the viscidness of the juice, by delaying the flux, and giving the parts more time to cohere or attract each other. But a strait course of the vessels increases the celerity of their fluid, whence a copious and easy secretion; but then it makes the secretion more un-uniform or impure, as we see in the urine.

§. 214. That the smaller arteries have (6.) different *degrees of density* or firmness, there is no reason to doubt; since we actually find it so by experiments in the larger branches. But the denser the capillary arteries, the more they resist the light and slowly moving particles, and yield only to the more dense ones, that have a greater impetus.

§. 215. And lastly, (7.) the velocity is greatly increased, when the excretory duct arises a good deal before the extremity of a larger arterial branch that ends with a short course; and is equally diminished, when the small secretory artery runs a long way capillary and cylindrical, whereby the blood loses the greater part of its motion in friction. Finally, from whatever cause the diversity of the blood's motion may arise, a greater velocity of it causes the secreted juices to be more dense or

heavy, more gross and un-uniform or impure : but slowness of its motion increases the attraction and viscidty, and probably renders the secreted juice more pure and homogeneous, as the similar particles, thus sorted and brought together, can better attract and join each other under a slow motion, so as to retain the larger canal, while the thinner parts go off by the lesser lateral branches. From hence it is, that only the impulse of the heart being too much increased, all the secretions are confused.

§. 216. From all that has been hitherto advanced, we may now begin to perceive, that, since the blood contains particles of various kinds, some sluggish or ropy, others mucous, others coagulable ; some, again, very fluid, others more dense and red, some glutinous, some watry and thin, others fat and gross (§. 175 and seq.) : among all these particles, those, which are the largest and most dense, as the red and yellow globules, will go on most towards the axis of the vessel, so as to pass on in a continued course from the artery into the trunk of the sanguineous vein, §. 37.

§. 217. Those particles, which are ramous, gross and sluggish, as the fat, must needs go off laterally by larger orifices from the sanguineous artery, by short ducts ; for long ducts would make a stop to so sluggish a juice, as the fat or oil. Therefore we see, that the circumstances or phænomena of the adipose secretion (§. 20.) agree with this description. Such parts as are coagulable, but specifically heavier than those which are merely watry, kept fluid
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only while the powers of life are in action; these pass off laterally from the sanguineous, into the pellucid arteries, less than the red arteries, with which they are continuous; whether these pellucid ones are continued on in the nature of trunks, sending off other smaller branches, like the least arteries (§. 40.); or whether they exhale their contents by a short extremity, like the vessels of §. 170.

§. 218. Thin watry juices may evidently pass off by any vessels continuous with the sanguineous ones or the lesser ones (§. 44.), provided they be only small enough to refuse the grosser juices: and this whether they come out from the sides of the larger arteries, or whether by a long continued course, and sending off all the grosser juices by large lateral branches, they, at length, end in a smaller pellucid canal instead of a trunk, like that which supplies the clear contents of the eye. To the production of these juices, the most simple fabric is sufficient: even a direct continuation of the secretory artery itself into an excretory duct, as we see in the urine. Therefore the ducts and vessels have here a straight and simple course, with few or no inflexions, and a proportionable velocity or celerity, as yet holds in the course of their contained juices.

§. 219. Such juices, as being watry, light, mucous and viscid at the same time, are consequently sluggish and less moveable; these may be easily secreted by short narrow ducts of a less diameter than to admit the fat, and appended to the sanguineous arteries; and, there-

therefore, it is evident, these will be separated from the blood more abundantly in some parts of the body than others, namely, where the velocity, received from the heart's impulse, is less, the flexures of the artery more frequent, and where the extent of the capillary artery shall be carried to a greater length.

§. 220. Whether or no ought we to ascribe to each particular part the ferments, pores, specific weights, or filters, which determine the nature of the humours to be generated? one, who admits of these, ought to consider the great difference there is in one and the same juice, separated in the same part of the body, according to the difference of age, course of life, &c. The bile in a foetus is generated sweet, the semen thin and without vermicles, the milk either none or very watry, the urine watry, mucous and insipid, the uterine mucus very white, the cutaneous vessels full of red juices, the lymphatic or watry juices redish, and the fat gelatinous. By the same organs, in an adult person, the bile separated is sharp or acrid, the semen thick, the milk sweet or oily, the urine yellow, thin and alcalescent, the womb discharges a menstrual blood, and lymphatic aqueous humours are most clear. But, even in the adult person, how different is the urine; at one time watry, at another thick or concocted, in a fever high coloured and heavier, full of salts and oils. The passions of the mind, which make no other change in the body than that of strictures in the nerves, yet wonderfully change the face of the secretions, and expel even the

the blood and bile through the vessels of the skin. Add to this the frequent disturbance of the secretions, and changes to which they are liable from slight causes; so that only an increased celerity shall cause several differing liquors to be secreted by one and the same organ: for serum and blood have been known to pass into almost all the passages of the secreted juices, into those of the sweat, tears, mucus of the nostrils and of the womb, and into the lactiferous, seminal and urinary ducts, as well as the fat. A true milk has been seen separated by glands in the thigh. When the urine has not been excreted by its natural course through some defect of the kidneys, ureters or bladder, it has passed by the skin, exhaled into the ventricles of the brain, or even into the whole cellular fabric. The perspirable matter of Sanctorius, however thin, is often by cold drove through the nose or kidneys, or by the same cause, by fear, or by medicines, is deposited through the excretory villi of the intestines. That exhaling viscid juice, secreted by the same organ with the fat, from which it so much differs, into the cellular substance, is deposited, takes place of the fat, is re-absorbed and alternates again with the same, §. 20, &c. A salivation supplies the place of the Sanctorian or cutaneous exhalation externally, and of the cuticular exhalation internally. The bile re-absorbed appears evidently flowing in the vessels of the eyes. Nor does there appear any thing in the fabric of any of the viscera or glandules that can fix or maintain the nature
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of the fecerned fluid; but that a greater or less velocity, or a stricture of the nerves, shall produce differently changed juices in the entire organs.

§. 221. It now remains for us to discover, how the secretions, in a healthy person, become pure or uniform. For all the juices, that have been lately secreted, (without excepting any, even the oil or fat itself) have a great many watry particles intermixed; so that none of the thicker juices seem capable of being formed without having a mixture of the thinner watry ones; how then do the semen, bile, fat, mucus, and other thick juices deposite their first watry state, and acquire their proper viscid condition and other qualities?

§. 222. For this end, therefore, nature has framed glands, with large and small follicles or reservoirs, for retaining the fecerned juices, from which the watry parts are required to be separated, to render the remaining part more strong and viscid. The mucus, at its first deposition, is thin and watry as yet, but little differing from the perspirable vapours or tears, in which state it distils into the cavity of the nostrils, wind-pipe, and intestines. This is not continually discharging, because the excretory orifice is less than the retaining cell or follicle, §. 189. and the excretory duct, being sometimes long and slender, so retards the juice that it cannot pass out but by the assistance of a pressure, or often, perhaps, not without a sort of nervous sphincter at its orifice, be from the irritating quantity or acrimony of the juice relaxed.

relaxed. This appears from the morning discharges of mucus by blowing the nose, coughing up from the lungs, and by sneezing after the nocturnal stagnation. In the mean time, the patulent veins, extended into the cavity of the follicle, absorb the more aqueous parts from the thin mucus, that it may become thicker, as it is retained longer ; but if, by the force of some stimulus, it be directly discharged after it is secreted, it comes out thin and watry. Examples of this we have in the urethra, in the nostrils and in the ear-wax ; as also in the bile, which, at its first separation in the liver, is watry, and has but little yellowness or bitterness. It is, therefore, retained by a large follicle or gall-bladder, and there digested or exalted by the vital heat, and its more thin or watry parts exhaled or absorbed by the veins ; whence the remainder becomes more thick, bitter and oily, or saponaceous. The same mechanism takes place in the semen, which, being reserved in the seminal vesicle, is there thickened, so as to be very viscid after long chastity ; but in repeated venery 'tis expelled very fluid. In some places nature has made this receptacle two or three times folded together in one and the same organ, when her design was to form a very thick juice. Thus the seminal passage is in the testicles reticular, in the end of the epididimis one large canal, ending in a larger vesicle ; whence the vessels at the testicle are narrow, and so again are the vas deferens with the prostatic duct.

§. 223. Hence, therefore, there are never any glandules placed in a part, but for the separation of a viscid juice; or if a viscid liquor is any where separated from the arteries without a glandular or follicular fabric intervening, it then always stagnates in some larger vesicle or cavity, of which we have examples in the seed, bile, synovia of the joints, and in the fat.

§. 224. A secreted juice may be likewise changed in its receptacle by irroration or the affusion of some new liquor. Thus the semen thickens by an affusion of the prostatic liquor, the chyle is thinned by mixture with the saliva and pancreatic juice, and that which distils from the villi of the stomach and intestines, and by an affusion of the bile it becomes alcalescent; and again the synovia or albumen of the joints is tempered by fat and medullary oil, §. 188.

§. 225. But the great use of the follicles and receptacles of glands is to preserve the juice, of whatever kind it be, for those times in which it is most necessary to be employed in the actions of life. Thus the bile is reserved for the time of digestion, the semen for due and lawful venery, and the mucus of the nose is accumulated in the night to temperate the force of the reflux air in the day.

§. 226. Therefore as nature has in this way framed machines, by which the juices are retarded in the large and small follicles, so she has made others to expel them at such convenient times. To some glands she has given particular

cular muscles for this use, as in the testicles of brutes, the urinary bladder and the gall-bladder; or else she has placed other muscular machines round them, which, by acting at convenient times, expel the contained fluids; as for example, in the muscular coat of the stomach and intestines. In other parts she has added contiguous and incumbent muscles to promote the discharge, as in the biventers and masseters of the lower jaw; or else she has again joined to them a kind of nervous irritability, which, being excited to action by an unavoidable stimulus, opens the shut passages to the milk, seed, tears, &c.

§. 227. The several particular juices, which are derived from the blood, we shall describe more accurately, under their respective organs. But before we descend to the particular secretions, it was necessary for us first to speak of secretion in general, and especially of that universal one, which is made of the nutritious serum or lymph through all parts of the body; thus we may next proceed to the apposition or accretion of it, to supply the deficiency of such parts as are daily wasting in the human body.

LECTURE VIII.

Of nutrition.

§. 228. **T**HE human body is made up of solids and fluids (§. 1.), of which the latter appear to be in much the greater proportion, if we consider their origin from a fluid nourishment, the great quantity of the blood (§. 167.), the proportion of the lights of the vessels to their fluid contents, the filling of the vessels by waxen injections, the small weight or bulk to which the body is often reduced by diseases, by putrefaction or a chemical distillation, or by an exhalation of what is more fluid.

§. 229. That the fluids are perpetually wasting is easily demonstrated. Those which are watry, are the most readily thrown out of the body. The Sanctorian perspiration, with that of the lungs, often amounts to three and four pounds per diem. But even the thicker coagulable juices are perpetually dissolved by the healthy human heat, equal to 96 degrees, joined with the attrition of the globules among themselves, and against the sides of the arteries (§. 148.); 'till being sufficiently volatilized, they, at length, fly off or escape. Even the urine is neither wholly a watry liquor, nor composed merely of the recrementitious parts of our aliments, but is in part formed of our worn-out humours, since it is found *alcalescent*
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and replete with the same kind of oil, earth, fixed air, and spirit, which the blood itself contains. Part of the bile also and of the intestinal juices are daily excluded by stool, to the quantity of some ounces. A further proof of this waste in the fluids, we have from the leanness and collapſion of the body that follows great exerciſe, fevers, the force of purgatives, &c.

§. 230. But the fluids are not the only parts of the body which waſte, for the ſolids likewiſe are daily conſumed by their perpetual actions in life. This is eaſily proved from the waſting cauſes themſelves; for the blood, being thrown with great impulſe by the heart into the convexities of the crooked veſſels, extends them in all their dimensions, both as to length and breadth; ſoon after which, the ſtraightened veſſels return by their elasticity again into their wrinkled or vermicular poſitions; and this change they ſuffer an hundred thouſand times in a day, by a force ſufficient to grind even wood or metals: ſuch a friction muſt, therefore, of courſe conſume the looſely cohering parts of our body, made up of a friable earth and glue (lect. I.), eaſily reſolvable by fire or putrefaction. This friction happens in all the veſſels, but is more eſpecially enormous in the leaſt veſſels; while the fibres are extended in length, the intermediate glue likewiſe, by the extension, loſes of its attractive force, and if the diſtending or impelling force does but a little exceed that of attraction, the glue muſt be expelled from the intervals betwixt the

earthy elements. This is confirmed by ruptures of the membranes of the aorta in old people.

§. 231. That there is a dissolution of parts in the extreme cut off, exhaling vessels, both external and internal, made by the force of the blood and juices, is demonstrable from the loose and free opening of the last elements of the fibres, only one of which adheres to the remaining part of each canal. From hence comes the scurf or fordes made by a consumption of the cuticle, the quick growth of the hair and nails, with the increase of the teeth, which is none of the slowest.

§. 232. That the cellular fabric of the vessels is wore away not only within their cavities, but likewise on all sides without, will easily appear from considering the very weak cohesion of this substance, so easily dissolvable by maceration only, with the violent attrition it suffers betwixt the impelled blood and the adjacent muscles, tendons, and contiguous bones. The circumjacent fat, indeed, abates this attrition, but does not wholly remove it.

§. 233. The cellular tissue or web-like substance, which makes the solid stratum or basis of the membranes and viscera, must necessarily dissolve and return into the state of a fluid, through an abrasion of fragments, made by the vibrations of the arteries, which are always annexed to it in every part of the body. The same dissolving effects likewise have the violent and almost incessant motions of the muscles, which, by the repeated flexions and extensions
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of their fibres, must operate thus in a very considerable degree: for the nature of things, in general, demonstrate this, since nothing more powerfully softens or dissolves the hardest bodies than a repeated and strong flexures of their parts; whence of course the same power will have the same effect in dissolving our cellular substance, composed but of soft fibres, lately made out of a gelatinous glue; and so far from solidity, that it contains many intermediate vacuities; with a distinct separation of its thin parts by intervening fluids, §. 10.

§. 234. Even the firmness of the bones themselves does not secure them from a slow dissolution; and a perpetual renovation; for that new stamina are formed in the hardest bones is evident from the morbid protuberances of the teeth in scorbutic patients; from the inflexions or curvatures of the fibres of the teeth round small leaden shot; and lastly, from the wonderful overgrowing or sprouting of those teeth observed both in brutes and men, which have long lost their opposites. Lastly, that the ossific juice or matter changes, and that the old carried off is succeeded or replaced by new matter, appears plainly from the degeneration of sound hard bones into the softness and consistence of flesh; from the venereal tophi or excrescences formed by a corrupt ossific juice, with the incurvation of the bones, that supervenes an acrimonious or vitiated state of the juices; and from the removal or cure of these by internal medicines: add to these, the red colour

lour that is introduced into the substance of the bones by giving madder with the food of animals, and the dissipation thereof, or restitution of the bones to their natural colour again by changing their diet. Lastly, that the bones of old people truly waste or decay, is confirmed by the experiences of many able anatomists.

§. 235. Hence, therefore, 'tis evident the whole living body is in a perpetual state of fluxion, consumption and renovation. The juices we see are fused, exhaled and expelled. The solids are broke and dissolved into the least scales and stamina, which, being taken up by the mouths of the inhaling vessels, and transmitted through the larger into the mass of blood, afford that earthy matter observable in the urine and in the substance of calculi, and præternatural ossifications formed in divers parts. This consumption is largest in youth, where all the parts are softer, and the impulse greater, the watry and gelatinous principles more abundant than the earthy. This waste grows less with age, but 'tis always considerable.

§. 236. There was, therefore, a necessity in nature to provide for this consumption of parts. In what manner the fluid parts are repaired will be easily demonstrable, if you consider from what we shall say on the digestive powers, that they send a chyle like milk from the aliments into the blood, replete with a thin butyraceous oil, and a liquid vegetable or animal jelly. So the globular juices arise out of
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the oily or fat particles, naturally of a globular figure and of a looser lighter texture than water, by the condensing powers, viz. the contraction or pressure of the arteries, and the intrinsic attractive force that prevails in the least vessels, where the globules are divided by very little water; and lastly, by the figurative power in the lights or sections of the least vessels, whereby they become dense globules of a certain diameter.

R E M A R K.

Fat or oil, both animal and vegetable, by triture with water, turns into jelly, and that again, by spontaneous rest and secession of parts, turns into oil; so that resins, by triture with alkaline salts and water, return to gums, and gums, by digestion, in plants with age, turn into resins. In like manner are animal fat or oil and jelly commutable one into the other. Though we cannot think the fat, under its intrinsic oily character, can make an organic part, either solid or fluid, even the most simple, as fibres and elastic globules, until it has acquired the elastic ropy property of lymphatic glue, by repeated mixture, triture, &c. So fat or oil must assume the nature of elastic glue before it can form organic globules, however loose, light or minute. Such light loose globules are abundantly supplied, and are ready formed with a nutritious jelly in most vegetable substances, especially fermented, as all pulse, bread, beer, wine, soops, &c. which globular matter, we know by the microscope, not only abounds in the nourishment itself, but in the chyle formed thence; so the globular juices of fish, flesh, milk, wine, beer, &c. less than red blood globules, may enter with the chyle, by the inhaling or absorbing vessels in the intestines, and by the abovesaid forces be compacted

into red, serous, and other globules. So likewise, as our author justly observes, fat or oil, being qualified or granulated, as it were, by the action of bile and other saponaceous juices, may, like the resin of plants, be reduced and ground into gelatinous elastic globules, still retaining so much of their oily nature as to be inflammable. Thus the fat, in consumptive people, turns again into blood and nourishment; and the redundant blood or nourishment from a ceasing of the menses at 50, or after other great excretions stopped, turn into fat, or else give birth to distempers.

§. 237. That red globules may be formed out of fat appears from their inflammable nature, §. 165. and that they may be formed of the condensed globules in the chyle is evident from the use of milk, as the best and most immediate matter for making blood in the foetus and children, confirmed by the experiments of Lewenhoeck, who observed the globules of chyle to be larger and looser or lighter than those of blood: and experience demonstrates the same, by which we know the chyle swims and circulates in the blood very distinct, both as to form and colour, for some (10 or 12) hours after a meal; but after a longer time, it disappears, and is found of a nature uniform to the blood itself; whence there is evidently a necessity for the chyle to change into the other animal humours.

§. 238. To form a coagulable lymph from blood then can be no great difficulty. For this we already have, long before, perfect in the flesh of animals, as in mutton; so that for this there is no other action required from our bodies,

dies, but to extract the ready formed lymph from the solid fibres and vessels, and transmit it thence to mix with our blood. And hence it is, that animal food affords the strongest and most durable nourishment, and the most immediate recruit to the several actions or forces. In vegetables, indeed, there is inherent a less quantity of the like, viscid, gelatinous nourishment; and therefore they nourish less. Yet, that vegetables already abound with such a glutinous jelly, as may merely, by the animal powers, be changed into coagulable lymph, is evident in herbivorous game and cattle, most of which, feeding only on plants, make thence the best glutinous lymph; and lastly, from the viscid nature of farinaceous vegetables themselves, being mixed with water, and from the nature of most juices obtained from plants.

§. 239. But that the other humours of the human body are generated of lymph, we are persuaded from the example of the young of incubated eggs, which are altogether completely formed, both solid and fluid parts, out of the albumen compacted; which is again confirmed and illustrated by the change of the lymph into an evaporable water, by a heat of 96 or 100 degrees, which watry lymph is then subalcaline; such as is the perspirable matter of all kinds.

§. 240. Nor is it very difficult to explain in what manner the wasting solid parts are repaired. For the lymph is viscid, and readily adheres or concretes into a solid, as we see, for instance, in the formation of polypusses; and,

by repeated concussions, (as with a whisk, &c.) the serous gluten, by removing the watry part, is readily drove together into a mass, §. 157. Therefore the foveolæ or little vacuities in the vessels or fibres, made by an abrasion or demolition of the earthy glutinous elements, are filled up by the lymph itself, compacted by the impulse of the blood, into which vacuities, being once received, it coheres partly by a broad surface to the other solids, and is in part figured, compacted and agglutinated by the impulse of the arterial juices driving against the circumference. [A great portion of this additional matter seems to be air absorbed and conveyed hither by the circulating fluids, and fixed into a solid with a greater proportion of earth, glue and water; since no dissolution ensues, unless the incorporated air be extricated, and set at liberty in elastic spherules.]

§. 241. As for the decrease or waste that is suffered in the extremities of the free pervious vessels and fibres, that seems to be restored by mere protusion, while the place of the decreased extremity is filled up by a production or elongation of the next continuous fibre. Thus intervals or vacuities are produced betwixt the protracted fibres, which are filled by new lymphatic glue.

§. 242. The wasted matter of the cellular substance is restored by the lymphatic dew itself, which transudes through it (§. 20.); for this being poured out wherever there is any waste or vacuities made in the fibres and plates of the said substance, being coagulable, it is, by
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the secession of its watry parts, joined with the pressure of the adjacent muscles and impulsions of the arteries, compacted together and changed into cellular substance. This is made clear from the change of vegetable juices first into a pulp, and then into a true cellular fabric; and from the morbid connecting filaments, which arise in the thorax or pleura from the lymphatic transuding vapours, &c. [A suppuration, and the conversion of vegetable juices first into a pulp, and then into a cellular substance prove the same.]

§. 243. In what manner the muscular and tendinous fibres are nourished, may be then more rightly explained, when we shall have a more perfect knowledge of their fabric. Yet it appears from a comparison of the soft pulpy muscles in a foetus, almost in every point fleshy, with the tendinous and but little fleshy muscles of an adult person, and from the great abundance of the minute vessels playing round all the muscular fibres; I say, from thence a muscular fibre seems to be nourished by a lymphatic dew, poured out into the cellular fabric that surrounds the fibre, with which it joins into cohesion by the muscular and arterial pressure.

§. 244. As the fabric of the bones is better known to us, so the rationale of their nutrition is more easy than the soft parts. They are composed at first of membranous fibres, which by degrees harden, while an ossifying glue is thrown into the spaces betwixt the fibres. This ossific juice is demonstrated from its filling the fissures that run betwixt the bony plates
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in a foetus, which in the adult become exorbitant knots of bone; from the inorganic stony crust, that is often formed round the bones; and from the frequent anchyloses, that are formed by the transuding of a confused bony matter coagulated betwixt any two bones: we have instances even where the whole hollow tubes of the larger bones have been filled by a redundancy of this ossific juice. But that the said juice is a true animal glue, of the same nature with the coagulable lymyh, appears from the jellies that are drawn out by fire from bones, horns, ivory, &c. so thick or viscid that they will make more than five times their bulk of water consistent, while the remains of the bone, from whence the jelly was drawn, are left very brittle or friable: but the same glue or jelly of the bones is also resolved by putrefaction, and then, like the lymph, it becomes wholly volatile, as we know from undoubted experiments. Lastly, that a fluid viscid juice may change into a dry friable nature, is evident from parallel examples in egg-shells, snails, and other testaceous animals; and finally, from the recent bones themselves transuding, bloody and viscid drops, soon changing into a hard bony nature, and from the solidity of a burnt bone restored by dipping in jelly.

R E M A R K.

Add to this, that among the nutritious elements of the bones, and other solid parts, the fixed, permanent or unelastic air (§. 2.) bears a very considerable proportion; for thus it abounds not only in the blood, but in the ossific and earthy juices it
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is even a sort of connecting magnet or glue, serving to combine and unite the earthy particles one with another, as appears from experiments on animal calculi, fossil stones, and other hard bodies : all which have the cohesion of their parts broke, and become friable so soon as the said air is expelled from them ; although the manner, in which this is effected, be difficult to describe.

§. 245. Thus it appears in what manner the body is preserved in the state wherein we find it in a healthy person, and how those losses are repaired, which are perpetually made by the actions of life itself. But the standard of nutrition varies in persons of different ages ; for during infancy more is added to the body than is thrown off from it ; but in old age the consumption or waste is greater than the addition. The former of these is called the *growth* or increase of the body ; and the latter its shrinking, *withering* or decrease.

§. 246. The foetus in its first rudiments was no more than a little limpid drop of a fluid consistence, as we shall hereafter make appear ; and even after it has had a month's growth, what are to be future bones appear as yet no more than gelatinous membranes. From such a smallness then as escapes the keenest eye is the foetus increased with so much rapidity by receiving a milky juice or nourishment, that within nine months it exceeds many millions of times its first bulk, weighing above a dozen pounds. From the time, therefore, of his birth, being exposed to the atmosphere, man increases in a less proportion, or grows every day

day more slowly, 'till, in the space of twenty years, he shall have acquired near twelve times his native weight, with a threefold or fourfold increase of length or stature. It remains, that we explain the causes of this increase and the quickness of it, during the first months; and why this quickness of the growth perpetually lessens.

§. 247. The wonderful extensibility of the foetus easily appears from the viscid mucous nature of its whole little body; for while the earthy principles are but few in a foetus, the watry and succulent are more abundant: the vessels themselves are also infinitely more numerous or abundant, as is evident to the eye, and from injections of the bones and membranes, in which an infinite number of vessels, not to be found in the adult, are visible enough; many parts are also seen vascular throughout in a foetus, instead of which, in adults, we find a condensed cellular substance, or an extravasated inorganic juice, as in the cartilages, coats of the vessels, skin, tendons, bones, &c. But the more numerous the vessels, the more easy is the growth or increase; since into them the juices are carried by the nearer heart, with a greater and more confined impetus. But in the more grown animal, the juices, transfused into the cellular substance, are almost stagnant, and the extending powers are less.

§. 248. But there is still another cause necessary to be taken into the account, namely, a greater proportion of force or impetus in the younger heart, with respect to the primigenial
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solid vessels and fluid juices in the human body. This is proved by the little heart or point, which immediately appears vivid and salient, when as yet none of the other viscera, nor even any of the future solid parts, make their appearance; and hence, of course, follows that greater frequency of the pulse, observable in younger animals. For how could the animal grow, if there was the same proportion of strength betwixt the tender vessels and heart of the foetus, as there is in the more resisting adult vessels and the heart of a grown person? And in this, if I am not mistaken, the greater irritability of the younger heart has a considerable share, by which the venal blood operates with a greater force on the heart of a foetus, than on that of an adult (§. 113.) For we see all the sensible organs in adults grow callous or less moveable, while in the foetus they are exquisitely tender and sensible; as for example, in the eyes, ears, skin and brain itself. And is not the same greater irritability also explainable from the greater magnitude of the head or encephalon; whence the nerves bear a greater proportion to all the other parts in younger animals?

§. 249. The heart, therefore, strongly exerting its force against the mucous vessels, easily extends them, together with the cellular substance that surrounds them, and likewise all the muscular fibres, at the same time, spread with variety of vessels. But all these easily yield to the prevailing force of the heart, because as yet they contain only a little of the
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§. 249. The heart, therefore, strongly exerting its force against the mucous vessels, easily extends them, together with the cellular substance that surrounds them, and likewise all the muscular fibres, at the same time, spread with variety of vessels. But all these easily yield to the prevailing force of the heart, because as yet they contain only a little of the
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rigid earth, but a great deal of the connecting yielding glue. [From hence come the more frequent hæmorrhages of young folks, who have a greater force of the heart and vessels not yet rigid.] But the bones are generated in such a manner, that, at first, a thick glutinous juice, being poured betwixt two parallel vessels, and there compacted together, forms a membranous fibre, which, by repeated pulsation of the vessels, becomes bony. But the bones increase, when these fibres are once formed, while the continuous lateral vessels, being extended lengthways by the heart, draw with them and elongate the said cohering bony fibres; by this means the cartilage, which every way terminates the bones, together with the cellular fabric (here compact and elastic) are repelled by the said fibres, which increase longitudinally betwixt each elastic epiphysis, so as to shorten and condense the said epiphyses. Thus the length of the parts of the body is increased; but, at the same time, intervals are left betwixt the elongated fibres of the bones, which, by this means, become cellular, as they grow more earthy. These intervals (by §. 20. and 244.) are filled with juices, which, in younger animals, are more viscid and glutinous than in adults; by this means the bony fibres and plates adhere one to another, from the glutinous matter fixing, like pegs, into their respective intervals or foveolæ.

§. 250. That the younger bones are of a more viscid gluey nature than those of adults and old people, is evident from the greater degree

degree of flexibility that remains in them, from their easier consolidating when broke, from the greater quantity of glutinous serum, and more abundance of jelly obtained from the joints or extremities of younger animals, and the great proportion of the cartilages to the bones themselves.

§. 251. But the animal grows or increases slower, as it becomes more adult. This is proved from the rigidity of the parts themselves, which were flexile in the fœtus; and from many parts of the adult skeleton being now rigid bone, which were before mere cartilage. For as the animal grows up, a multitude of vessels are effaced or closed up into fibres, beat together by the internal pulsation of the larger artery that lies betwixt them, or upon whose coats they are spread; and the lights of these being occupied by solid matter, they become in a great proportion stronger; namely, by the bony juice poured into the clefts betwixt the bony fibres, or by condensing of the cellular substance in all the membranes in the coats of the vessels, &c. But every where in all parts of the body a great portion of the more watry part of the juices being exhaled, the cellular filaments approaching nearer, attract each other more powerfully, cohere more strongly, and resist extension with a greater force. At the same time the glue itself, which every where adheres to the bones and solid parts, becomes drier from an expulsion of the watry principle, by the so often repeated pressures of the arteries and muscles. Hence the
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the proportion of earth in the animal every day increases.

§. 252. Thus will all parts continue to augment in bulk and density, 'till they arrive at a terminus or balance, beyond which the heart will be no longer able to make an extension of the solids. This terminus then is present or compleat when the cartilages belonging to the epiphyses or heads of the bones, are, by degrees, so extenuated, that they can become no thinner, but like a pellicle, no less firm than thin, make a permanent resistance both to the heart and to themselves. At the same time, and from the same causes, all the cellular fabric or expansions (except in a few places) are throughout the whole body compacted or hardened, and all the membranes of the arteries, the muscular fibres and the nerves themselves acquire from the said causes (§. 251.) such a degree of firmness, that they can be no longer extended by the force of the heart:

§. 253. The cellular web-like substance, however, whose plates are naturally loose, lodged in several cavities of the body, still gives way to the impulse of the fat and sometimes to that of the blood, whereby it swells or enlarges in several parts, so as to cause an increase of the body, not in length or stature, but in bulk or thickness. But this fatness of the body, after its full growth, seems to follow hence, that less nutritious matter being deposited from the blood, because the growth now ceases, there is a redundancy of it towards the other secretions; and because the resistance to the passage
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of the humours through the least vessels is now increased from their greater density or induration; therefore the sluggish juices (such as make fat) more easily recede laterally from the least arteries into the cellular diverticula. But again the sluggish secretions must, at this time, be increased, because the relative or comparative force of the heart, as 'tis properly called is now diminished. For the rigidity of the parts increases the resistances, while the force of the heart itself does not appear to have gained by the said rigidity; because we know it is a muscle to the strength of which conduce flexibility, a plenty of nervous juice in proportion to its solid fibres, and a considerable portion or influx of the red blood itself; as we shall explain more at large, when we come to speak of a muscle. But all the foresaid additions to the body are so far from being increased from old age, that, on the contrary, they diminish in it.

§. 254. But, moreover, the whole body, which is supposed to remain in a permanent state, is really in a perpetual flux, and never at rest. The change, which is made at the expence of vascular property, never ceases; for perpetually some vessels go on to be effaced or closed up into solid filaments, according as the pressures from weight, the force of the muscles, or of the heart, continue to act more upon certain parts. Hence we observe, that those parts of the body first grow rigid, which are oftener used or laboured in every artist. All the cellular plates likewise are continually condensed or hardened, while the glue and nourishment it-

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self become more dry and earthy. From hence proceeds that rigidity of the joints and bones so commonly observable in old people, the frequent change of their cartilages into a bony nature, with a hardness of all their soft parts, from a deficiency of the flexile glue, remarkable even in the cellular substance of the brain, heart and arteries, with a greater specific gravity of their whole body, all its particular parts, even the crystalline lens itself not excepted.

§. 255. Lastly, the glutinous, attractive and nourishing property of the juices themselves, which belong to the human body, is diminished by the frequent use and introduction of saline foods, inflammable or spirituous drinks, with errors and excesses in diet of all kinds; whence the blood and lymph, at length, degenerate into a friable, acrid and little gelatinous disposition. This is proved from the slow consolidation of wounds and fractures in old people, from the remarkable fætor of their breath and urine, from the increase of saline and diminution of watry parts, observable in their blood, and from the opacity or discolouration of such juices, as were formerly colourless or pellucid.

§. 256. In the decline of life, therefore, the intervertebral ligaments, by degrees, grow dry, hard and ossified; whence the spine loses its rectitude by a contraction of the vertebræ towards each other forward, by which the height or stature of the body is lessened: the tendons, having lost a great part of their flexile glue, become very shining, hard and cartilaginous;

nous; and even the muscular fibres themselves by repeatedly pressing out the blood and juices from their intermediate vessels, change into a dry, tendinous, white nature: all the vessels, and more especially the arteries, indurate by driving out their watry juices, and frequently put on almost a bony consistence, while the plates of the loose cellular substance are contracted into a kind of hard membranes. Thus the excretory vessels, being in all parts compressed, and the exhaling ducts or pores closed or beat together, an universal dryness ensues, while the necessary depurations of the blood are diminished. From hence the rigidity of old people is increased, and their blood assumes a more dry earthy texture, so as to deposite a true earthy matter, instead of a moist vapour, throughout the cellular fabric, in all parts of the body. The truth of this appears from the numerous instances of indurations, and bony incrustations by an effusion of this matter into the fabric of the arteries, membranes, upon the surfaces of most of the bones, especially the vertebræ, and as we sometimes perceive in the very softest parts throughout the whole body.

§. 257. In this manner is the way opened to a natural death, which comes on so soon as the heart, now callous and feeble, or nothing increased in strength, sinks under the load of all the increasing resistances. The lungs, now less pliable, oppose too great a resistance to the right ventricle of the heart on one side, as on the other side, does the whole system of the

capillary arteries, which, indeed, in all stages of life, oppose many considerable resistances to the heart (§. 160.) Thus the blood, gradually losing of its motion, at length stops, and is more especially collected on the right side of the heart, while the way through the lungs is shut up; 'till at length the pump-like engine, we call the heart, after a few struggles or palpitations, becomes itself quiescent under the load of stagnant blood, which now begins to thicken or turn grumous.

§. 258. The limits of this natural dissolution, nature herself has fixed or appointed to all sorts of animals; although her proportions therein are not yet sufficiently known to us. Man, being an animal remarkable for his longevity, easily spins out a natural life to twice the length of that we observe in an ox or an horse; since frequently he attains the age of an hundred years, and sometimes that of an hundred and fifty. The feathered tribe, we know from certain experience, are naturally very long livers; and these are again exceeded by fish, which, being furnished with cartilages instead of bones, grow perpetually.

§. 259. Thus death appears to be absolutely necessary and unavoidable from those laws of nature, with which we are at present acquainted; only the bounds of it may be changed by a difference in the proportion of the heart to the other solids, by a variation in the powers digesting the aliments, with the particular constitution or nature of the blood, and the heat of the external air. For the larger vessels
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will inevitably compress the smaller, the glue will of course grow more dense and hard, as its watry parts exhale, and from the same exhalation, nothing can hinder the cellular threads and plates from running into more powerful attractions and cohesions. Yet this rigescence of the solids may be, in some measure, retarded, and the dry acrid temperature of the blood and juices may be lessened by a moderate course of life ; not exercising our machine too much, either by motions of body or passions of mind, by living upon vegetable food and drink, and shunning excesses of all kinds, even of cold itself.

§. 260. But it may be questioned, whether we are to believe, that new vessels and new parts may be generated in the human body, or be again restored ? whether the regeneration of parts, cut off from the polype, sea-nettles, most of the worm tribe, snails, and the renovation of the stomach each year in crabs, and the tails of lizards, &c. may be esteemed sufficient argument for such a belief ? to which add the reproduction of true bones in the place of those lost ? whether we are to refer hither the natural reparation of the hairs, nails, feathers, &c. which are by no means inorganic ? to which add the new flesh generated in wounds, renovation of the skin, reproduction of the scrotum, the callus of bones, &c. ? the question, indeed, appears difficult. It seems then a common privilege, that insects, and particularly those specified, enjoy a very slow motion of their viscid, glutinous juices, in a very

simple fabric; whence the said juices do not run out as in us, but, by attraction, gather and cohere with the rest of the body. In man, the membranes we see formed in hydatids, the flesh in wounds, and the callus which fills up broken bones, and even occupies the place of whole bones that have been lost, are produced from the glutinous juices, compacted by the pulsation of the adjacent arteries, and are a continuation from the divided vessels, or a production of the extremities of the periostium within the wound. But we see, from the reunion and growth of parts cut off and sewed on again, as in the nose and lips, or only replaced, as in the teeth, that there is a natural necessity for divided vessels to unite and close with opposite vessels divided. But for any of the more complex, large and organical members to be reproduced, is a thing unheard of; nor can it be admitted in the human body, which has so great a force of the heart, such a putrescent disposition in the stagnant juices, and such a complexity of fabrication in all its parts, very different from the simplicity nature observes in the formentioned insects.

R E M A R K.

However unknown to us may be the intrinsic fabric, number and affections of the particles, pores and interstices in the least fibres, membranes and vessels, 'tis certain, that in the human body, as well as in vegetable and fossile, mixed and text bodies, they have a power of affinity, by which they select certain particles from the common incrementive fluid, and then combine, apply and change them,

them, so as to become part of themselves; and this in a most regular geometrical fabricature, according to the laws of affinity and mutual attraction or appulse given to the parts of matter by its creator. How regular and constant, in their figure and combination of parts, are the crystalizing salts, the mixed and text fossils, stones and shells, from this principle merely. This power, though it be not absent in vegetables, is yet governed by, and dependent on the force of an organic or tubular attraction and temporary impulsions from the air, heat, &c. So likewise in animals, the tubular and corpuscular forces are modulated by centrifugal impulsion through distractile canals; joined with external resistances from confining, but extensible integuments. Each of these powers have their limits and proportions respectively one to another towards a natural, healthy organization and fabricature; and in the human body are subject to so many and different termina, in the scale of combination, from the more simple to the more complex organs, as profuse volumes and languages arise from a few letters; that it is equally impossible as unnecessary, to sum them up by all the powers of algebra and geometry conjunctly. If particles of salts and other fossils have an intrinsic power, by which they accede, concrete, and build up a regular texture; why may not the same corpuscular affinity join with tubular attraction, and hygraulic vascular impulse, to build up a regular organization, or even to increase or maintain it when so built. These powers in the human body seem to be engrafted one upon the other: so that where vascular impulsion ends, there tubular attraction begins; and where that ends, corpuscular affinity takes place, but in such a manner, that they always operate conjunctly to the same end, though they may have different proportions in different parts;

so, we may say, the hairs, like rushes, vegetate by impulsion, or that the enamel of the teeth petrifies by vegetation. From all which we conclude, that organization, as well as nutrition, are ultimately finished by that corpuscular affinity, which is more remarkably conspicuous in the accretion of mixed and text bodies, joined, however, with tubular attraction and vascular impulsion from the heart.

§. 261. We have hitherto considered what belongs in common to all the vessels of the human body in general; it, therefore, now remains for us to go on to those offices which belong to each artery in particular. Accordingly we chuse to speak first of the pulmonary artery, as well because it first goes out of the heart from its right ventricle, as because the aorta itself receives nothing but what first comes to it through that artery (§ 107.): but then to understand the uses of the pulmonary artery, requires a previous description of the lungs, as the organs of respiration, to which, therefore, we proceed.



LECTURE X.

Of respiration.

§. 262. **T**HE bags of the pleura (§. 75, 76.) are exactly filled by the *lungs*; for so we call the two viscera, which are distinguished into right and left, in figure answerable to that of the bags themselves which they fill, having a broad basis below; they are terminated above at the first rib, by an obtuse point or cone. The anterior face of them is flat, their sides convex or round, internally or in their middle concave, forming a concavity sufficient to contain the heart. The right lung is larger than the left, and more frequently divided, or half cut through, into three distinct lobes or portions; but the left lung is not so often divided into three. They are freely suspended by the great blood vessels, at liberty on all sides, excepting where the external membrane of the pleura, departing from the thorax to the lungs, and to the diaphragm, forms there a mediastinal ligament. Betwixt the lungs and pleura is found a watry, or rather serous vapour, of a coagulable nature, like that of the pericardium (§. 80.), which vapour transudes from the surface of the lungs, and is sometimes increased to a dropsy, or else concreting into fibres, joins the lungs to the pleura.

§. 263.

§. 263. The external membrane of the lungs is a simple, thin continuation of the pleura, spread all over them, from the adhesion of the great blood vessels of the heart, yet so as to be capable of retaining wind easily without breaking, after being separated from the lungs. The same membrane covers the interstice or mediastinum of the lungs, like a bridge.

§. 264. The structure of the lungs is a heap of lobes separated from each other by intermediate intervals, in which is extended a loose cellular substance; the first division of them is into two extreme lobes, which are larger, and one middle one, which is less, yet cohering together, although afterwards they are again subdivided internally through a long series into lesser lobules down to the least, 'till at last the small lobules terminate in very small cellular membranes, which, in adults, are variously figured and full of air, which passes freely on all sides from one cell to another, by their open communications. These vesicles of the lungs, therefore, do not receive the air by a single orifice from the wind-pipe, as into an oval grape or vial, but the air exhaling from the least branches of the said wind-artery, is admitted in such a manner into their irregular spaces, that it freely spreads through them, from any one part of the lungs into all the rest, and returns again in like manner. This is demonstrated by inflation, which drives the air even through the least branches of the wind-pipe into the smallest lobes; from whence it
readily

readily passes into all the rest. Nor is the cellular fabric of the intervals shut up from the vesicles of the lungs, nor are the lesser lobes surrounded by any peculiar membrane.

§. 265. The air is drove into these vesicles through the wind-pipe, which arises from the larynx (hereafter to be described), and from that only receives its air. The first part of this wind pipe is single, and descends along the smooth bodies of the vertebræ of the neck, partly fleshy and partly cartilaginous, having the gula or œsophagus behind, and a little to the left of it; namely, within the cellular substance that surrounds the wind-pipe, follows a canal, made up by a succession of cartilaginous and muscular rings: these are thin and elastic, flatter and thicker in their foremost part, but thinner in their posterior extremities, which are conjoined together by strong transverse muscular fibres, which adhering firmly to each extremity of the cartilage, compleat the circle. But the lowermost bronchal cartilages, within the substance of the lungs, are compleat rings, lessening in their sizes.

§. 266. The muscular or fleshy rings, alternately placed with the cartilaginous ones, are made up of red muscular fibres. Some of these are transverse, connecting the detached ends of the annular cartilages, others descend from each upper to the next lower ring. But other muscular fibres again descend perpendicularly behind from the cricoide cartilage, and having reached below the first division of the bronchia, vanish within the lungs. The transverse

verse fibres contract or lessen the diameter of the wind-pipe, as the longitudinal ones render it shorter. Also within the lungs, betwixt the imperfect rings, is found a sort of muscular fabric, but less uniform.

§. 267. In the cellular coat, which surrounds the muscular one, but especially in the back part of it, along the posterior interval, that is betwixt the cartilages, are placed numberless simple glands, which open by very small ducts, like pores into the cavity of the wind-pipe; by which pores they deposite a watry and pellucid mucus into that cavity; which mucus, being without the least acrimony, not hardening into a scaly substance, is of the greatest use in defending these most sensible membranes from being injured by an impure air, full of particles, which, by their mechanical figure or chemical acrimony, might be very troublesome. Lastly the internal tube of the wind-pipe is compleated or lined by a membrane, which is continuous with that of the mouth, smooth, soft and very irritable.

§. 268. The vessels of this part of the whole wind-pipe in the neck, come from those of the lower thyreoids; in the thorax, from other small branches of the subclavian trunks or the mammaries, or the bronchials, properly so called. Small nerves to it are numerous from the recurrent and intercostal.

§. 269. In the upper part of the thorax, the wind-pipe is divided into two similar branches resembling the trunk itself, and formed like that of imperfect cartilages, also furnished with

with fimilar glandules ; each of which branches enters the lung to which it corresponds, only the right is something shorter than the left. Having entered the lungs, the cartilaginous rings change into fragments, which become more and more difform and tessalated, or angular, intermixed with the membrane of the pleura, 'till, at length, the cartilages decreasing, terminate the last branches of the bronchia into mere membranes. The glandules here are like those before mentioned (§. 267.) But there are other conglobate glandules of the lymphatic kind (§. 183.) placed at the division of the branches, and upon the trunk of the wind-pipe, and about the lungs ; but these are not of use to the wind-pipe.

§. 270. The last branches of the wind-pipe are invisible, which exhale the air into the cellular spaces of adult lungs, and likewise receive the watry vapours exhaling from the arteries into the said spaces ; from whence they are thrown out by expiration.

§. 271. The blood vessels of the bronchia are the *arteriæ & venæ bronchiales* ; the former are almost constantly two, one coming from the upper intercostal of the aorta, which is distributed either to the right only, or to both the lungs ; the other, from the trunk of the aorta itself, goes to the left lung. Sometimes there are more than two bronchial arteries to be seen ; as when there are three, by the addition of a second from the aorta. But sometimes again there is only one artery in common. The bronchial veins are most commonly two,

one right from the vena azygos, the other left from a peculiar branch of the subclavian vein. These blood vessels travel together with the branches of the wind-pipe, and descend into their membranes in such a manner, that the pulmonary arteries, in their way, inosculate with their contiguous arteries, as the veins likewise communicate with each other. There are some instances where the pulmonary vein itself has given small branches to the lungs, to the wind-pipe, and particularly to the surface of the lungs.

§. 272. But there are other larger vessels belonging to the lungs, called the pulmonary artery (described §. 100 and 102), and the pulmonary vein (§. 104.). The trunks of these blood vessels likewise accompany the branches of the wind-pipe in their course through the lungs, surrounded with a good deal of cellular substance, which substance, being increased, composes the ultimate spongy fabric of the lungs themselves. Within this cellular fabric, and likewise upon the ultimate spaces or cells, the air vessels and blood vessels are subdivided, spread and interwove somewhat like the meshes of a net; and here the small arteries (§. 261.) exhale a plentiful vapour into their cells, and the veins absorb a watry vapour from the same cells. Hence water tinctured, the whey of milk, or a thin waxen injection, being urged into the pulmonary artery, flows with a froth into the wind-pipe; or on the contrary, being urged from the wind-pipe into the lungs, they penetrate into the pulmonary artery. In like manner,

manner, injections pass from the pulmonary vein into the wind-pipe, or from thence again, they may be forced into the veins. Lastly, a liquor, injected by the arteries, readily enters the pulmonary veins, and the reverse.

§. 273. The lymphatic vessels, as in other parts, form a net-work upon the surface of the lungs, from whence there are branches conveying the lymph to the cavity at the back part of the mediastinum, and to the small glands, which lie behind the œsophagus, opening, at last, into the thoracic duct. The pulmonary nerves are small, from a nerve of the eighth pair, which descends and subdivides according to the course of the bronchia. There are also some small nerves to the lungs from the recurrent, and likewise from the cardiac plexus, which enter together with the large blood vessels.

§. 274. The quantity of blood, which enters into the lungs, is exceeding great, equal to (or even perhaps greater than) that which is sent in the same time throughout the rest of the whole body; which, therefore, demonstrates some very considerable use, proper to this viscus. And that this use depends manifestly upon the air, appears from the universal consent of nature, in which we scarce find any animal without breathing; also from the structure of the lungs in the fœtus, in which, for want of air, they are useless, receiving only a small portion of the blood, which the pulmonary artery conducts from the heart. We are now, therefore, to speak of respiration, by which the air is drawn into, and expelled from the lungs.

§. 275.

§. 275. The element of air appears from the principles of philosophy, to be an elastic, invifible and fonorous fluid. But the atmospheric air, which we commonly receive into the lungs, is impure, filled with a great quantity of watry vapours, with the feeds of plants and animals, and other foreign matters, but in very minute particles; fo that it weighs 850 times lefs than water. This air, which furrounds the earth on all fides, being preffed by the incumbent columns of its own mafs, perpendicularly, laterally and in all direCTIONS, enters, wherever it meets a lefs refiftance, and with a confiderable force, as appears from experiments made with empty or exhausted veffels, and by the air-pump.

§. 276. This air is excluded from all parts of the human body by the furrounding clofe fkin, which, even when dried or tanned, is impervious to the air; but more fo as under the fkin is placed the fat, making an equal refiftance to the narrow openings of the abforbing veffels. It, therefore, now remains for us to enquire, why the air enters the lungs of an adult perfon, & for with this they are, in a manner, constantly full, and of courfe are equally preffed, and refifting againft the weight of the whole atmosphere: but that the lungs always contain air is evident, becaufe, however clofe you compress them, they will be ftill lighter than water; and even in the foetus, after they have been inflated but a few times, they always swim, whereas, before breathing, they fink to the bottom

bottom of water, if they have as yet not given admittance to the air.

§. 277. The equilibrium of the air's pressure being removed in any place, it constantly descends or flows that way, where it is least resisted (§. 275.). Therefore, for the air to enter the lungs, they must make a less resistance to it than before; namely, the air, which is already in the cellular fabric of the lungs, must be rarified; but this effect will follow, if the cavity of the thorax, in which the lungs are contained, and which they exactly fill, be dilated (§. 284.). Thus the air, which is always in the lungs, expands into a larger space, by which, being weakened in its spring, it makes a less resistance to the external air; and consequently a portion of the said external air descends into the lungs, sufficient to restore the confined and rarefied air, filling the lungs to the same density with that of the external air. See §. 290 and 293.

§. 278. We must, therefore, describe the powers, which dilate the thorax to produce this effect. The breast or *thorax* is a sort of craticle or cage made up of moving bones, muscles and cartilages; being of a figure almost elliptical or oval with the narrower end of the obtuse cone upwards, and somewhat compressed before, but behind divided by an intermediate eminence of the spine. In the upper and lateral parts of this bony craticle are placed the lungs; in the middle and lower part of these lies the pericardium and heart;

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after which, a portion of the arched basis is taken up by some of the abdominal viscera.

§. 279. The shell and pediment of the thorax are composed by twelve ribs on each side, with the sternum before, and the spinal vertebræ in their middle behind. The firmness of these vertebræ, as well from their being locked by processes into each other, as by their connexion with the ribs, makes their union not easily dissolvable, but very sufficient to support the ribs, as upon a solid basis. The *ribs* are in general bent in the form of an irregular arch, having their greatest curvature in the sides of their back part, but extending thence in their fore part towards a right line. The bones of the ribs lie sufficiently parallel with each other. The greater part of the rib, which is bony, is round and thick backward, but thin and flat forward; while the other part forward is completed by a cartilage, which, in general, continues the figure of the rib, in a flat broad concavity of whose bony extremity it is fixed and grows from.

§. 280. The posterior and bony thick part of each rib terminates in a head, along from which, in the body of the uppermost and two lowermost ribs, runs a cavity or groove, formed in the other ribs betwixt every two adjacent margins, which lie one towards the other. The vertebræ are tied to the ribs by strong ligaments, of which the principal spread from each rib like rays into the next adjacent vertebræ, other ligaments tie the transverse process
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to the tubercle of the rib, and others tie the ribs one to another and to the transverse processes likewise at the same time. Moreover, betwixt the angle of incurvation and the juncture with the vertebræ, each of the ten upper ribs send out a protuberance, which, being articulated with the plain side of the transverse process of each vertebra, are so tied by short and strong ligaments to that process, that the rib has liberty to make a small ascending and descending motion, but with a considerable degree of firmness.

§. 281. Among the anterior cartilages of the ribs, the seven uppermost reach to the sternum, and enter into small notches or cavities, which are incrufted with a cartilage in the sides of that bone, to which they are also made fast by stellated ligaments. Of the five remaining ribs, the uppermost is fastened to the seventh preceding, and that to the next lower by peculiar productions of the cartilage, firmly cemented with its fellow, and covered with a strong cellular membrane, by which they form a continuous margin or extremity, which is, at last, also fastened to the sternum; but in the twelve lowermost ribs they are at liberty or detached, adhering only to the muscles on each side. These cartilages of the lower ribs are connected by strong ligaments to each other and to the sternum.

§. 282. The course or direction of the upper rib is descending, but the second rib joins the sternum almost in a right angle, while the others ascend from the spinal vertebræ, but

more especially raise upwards, as they come nearer towards the sternum. But the bony part of the ribs is placed in such a direction, that the uppermost have their sides in the fore part, very much declined forward almost transversely; the next or second ribs are placed almost to a perpendicular, while the middle ones in their lower part project a little outward or forward. Therefore the firmness of the ribs varies, the uppermost being short rather grow into the sternum than form a joint with it; and they transversely resist it with a considerable strength on each side. From thence the mobility of the sternum increases downwards, 'till its bottom, adhering only to muscles, has the most easy motion.

§. 283. The sternum, in general, is a thin spongy bone altogether, one in adults, but is variously divided into several in the foetus and younger subjects. Its upper end resembles an octogon, at the broader part of which it is articulated with the clavicles, which are jointed very closely with the triangular head of the sternum, and with the first rib on each side. The sides of the sternum receive the extremities of the ribs, each into their respective angular cavities, while the lower part of the sternum terminates in a detached bony appendix, which is, in part, cartilaginous, capable of moving and changing its position under the denomination of the Ensiform cartilage.

§. 284. In order, therefore, to rarefy the internal air, that the external might rush into the lungs, it was necessary for the thorax to be

be dilated. For thus all the sections of the thorax form right angles, and its capacity is increased. This motion is performed by various muscles, which either operate constantly, or only at certain times. The intercostal muscles, therefore, all of them act perpetually in elevating the ribs. For, by this name, we understand twenty-two muscles, of which, eleven are external or next the skin, and as many internal, separated from the pleura only by fat or cellular substance. The beginning of the *outer intercostals* is at the posterior articulation of the ribs (§. 280.); but the termination of them is in the anterior bony part of each rib, at some distance from the cartilage, in such a manner, that the remaining space betwixt the cartilage and sternum to the muscle is filled by a tendinous expansion. The course or direction of these muscles is such, that the fibres descend obliquely forward, from the lower edge of the upper rib to the upper edge of the lower rib. And that their action is to elevate the ribs, all authors unanimously agree; because they thus descend from the upper less moveable to the lower more easily moveable bone, in such a manner, that their lower point lies more distant or remote from the hypomochlion or point of motion, which is in the costal articulation with the vertebræ, considering the rib as a lever.

§. 285. But the *internal intercostals* arise at some distance from the vertebræ, almost at the outer tubercles of the ribs before-mentioned (§. 280.); from whence their origination con-

tinues as far as the sternum, into which the uppermost of these muscles are inserted above. The direction of these is contrary to that of the former, except the anterior part of the first or uppermost of them; so that they descend from the lower margin of the upper rib backward, to the upper edge of the lower rib forwards. Therefore some doubt of their action, because their lower part is inserted into that portion of the rib, which is nearest its articulation with the vertebra, and which, therefore, seems to be the least moveable: However, they elevate the ribs, notwithstanding this; for the great firmness or immobility of the upper rib, exceeding that of the lower, is evident from the articulation, weight, and ligaments there formed, which surpasses that mobility, arising from the greater distance of the center of motion: this appears from the dissection of living animals, in which we see the inner intercostal muscles operate in the elevation of the ribs, and rest in the depression of them; also from a flexible thread fixed to the rib of some human skeleton, and drawn in the same direction with that of the fibres of the inner intercostal muscles, by which means the lower rib will be always approximated towards the upper: the greater firmness also of the upper ribs proves this, as they serve for a fixed point to the lower ones; for the first or uppermost ribs are from eight to twelve times firmer and less moveable than the lower true ribs; but the difference of distance in them, from the center of motion, is scarcely the twentieth part of the length of
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their whole lever. [Lastly, the elevating power of the internal intercostal muscles appears plainly by experiment in a dead subject, whose thorax, being raised or inflated, those muscles swell or contract.]

§. 286. By the action, therefore, of these muscles, the thorax is elevated; since as the ribs turn upon their articulations, their extremities thereby descend and form larger angles; but from thence in the middle of their arches, by ascending, their lower edges are drawn upward. At the same time, the sternum is thrust out forward more from the vertebræ and from the ribs. Thus the ribs recede farther from the vertebræ, the right ribs depart from the left, and the diameter on all sides, betwixt the right and left ribs, betwixt the sternum and the vertebræ, is every way increased to about two lines or twelfths of an inch: and therefore this enlargement, following in every imaginable section of the thorax, will sufficiently dilate the cavity of the breast. This action of the ribs is more particularly complete in women, and in men who have no shortness of breath. But this dilatation alone is not sufficient for healthy breathing, nor is it so conspicuous or evident in men, although, in them, the intercostal muscles, by retaining and elevating the ribs, very much assist the inspiration in a tacit or unactive manner, while they afford a fixed point to the diaphragm, that the whole force of that muscle may be spent not so much in depressing the ribs, as in urging down the abdomen. The bigger part, therefore, of the

space, which the thorax gains in inspiration, arises from the action of the diaphragm.

§. 287. By *the diaphragm* we understand, a muscle, expanded in a lenticular or small oven-like curvature, by which, in general, the pulmonary bags are parted off transversely from the abdomen, in such a manner, that the middle of the septum is nearly the highest or uppermost part of its convexity, by which it supports the pericardium, while its lateral parts, which arise from the sides of the thorax and loins, have on all sides a descending obliquity, but the most backward, as it descends lowest of all at the spine. The fleshy portions of this muscle arise before from the inner side of the ensiform cartilage, and from the inner face and extremity of the seventh, eighth, ninth, tenth, eleventh and twelfth rib; after which follows an interval, in which the naked pleura lies contiguous to the peritonæum; from thence the muscular legs or appendices of the diaphragm, which are much the strongest part of it, being collected on each side into two, three or four round muscular portions, arise fleshy from the transverse process on each side of the first and second vertebræ of the loins, and tendinous from the middle of the body of the second, third and fourth of those lumbal vertebræ.

§. 288. All the fore-mentioned muscular fibres, (§. 287.) becoming tendinous, form the center of the diaphragm, which resembles, in figure, an obtuse index of a sun-dial, having the middle of the larger angle supporting the
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diaphragm, while the lateral angles or wings descend backward, the left being narrower than the right. This center of the diaphragm is more moveable and at liberty than the rest; except in the middle of its tendinous part, near the fleshy margin, where the incumbent heart makes a resistance, but the lateral parts and the fleshy portions belonging to them, are the most moveable.

§. 289. There are two considerable openings through the diaphragm, of which that on the right side of its tendinous part is somewhat square and lined or circumscribed by four strong tendinous portions; the left opening is elliptical betwixt the two muscular legs, or right and left portions, which arise from the middle of the bodies of the vertebræ of the loins, under which opening they decussate and cross each other once or twice, but above they end in the tendon. This left opening is, therefore, drawn close together in the contraction of the diaphragm, while it is probable, that the other opening remains immovable; because the tendons of muscles are but little changed in their motion of contraction.

§. 290. The structure of the parts, and the dissection of living animals demonstrate, that the fleshy portions of the diaphragm, which on all sides ascend from the firm parts to the middle and more moveable portion of it, do, by their contraction, depress the same, and by that means draw downward the lateral bags of the thorax, which contain the lungs (§. 75.): and by this means the perpendicular diameter
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of the thorax is considerably increased, while all the viscera of the abdomen are compressed and urged against the resisting muscles of the abdomen, with the resisting bony sides of the pelvis. So that the diaphragm almost alone performs the office of respiration in a healthy man, who is at rest. [The lungs themselves are altogether passive or obedient to the action of the air, ribs and diaphragm; to which they are pressed into such close contact on all sides, that when the thorax is denudated or cleared by the knife, leaving its capacity entire, the lungs appear filling out the pellucid pleura and diaphragm, as close as an onion to its withered skins.]

§. 291. But in larger inspirations, which receive a greater quantity of blood driven into the lungs, and when there is any obstacle or difficulty opposed to the action of the lungs themselves; in those cases, several other powers conspire to dilate the breast and raise the ribs: which powers are inserted either into the thorax, clavicles or scapulæ, such as the *scaleni* muscles, *trapezii*, *cervicales descendentes*, *serrati superiores*, and *pectorales*, together with the small elevators, of which a more ample description may be had from professed systems of anatomy.

§. 292. We have hitherto surveyed the powers (§. 209, 286.), which are able to increase the capacity of the thorax in all its dimensions; it, therefore, remains, that the air (§. 275.), which is a heavy fluid, and pressed on all sides by the incumbent columns of the
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atmosphere, must now enter the thorax or lungs by that greater force which it has over the little rarefied air already in the lungs, or yet more powerfully, if they contain no air at all. In this action, therefore, which is called inspiration, the bronchia or branches of the wind-pipe are every way increased, both in length and diameter; because all the diameters of the thorax are increased: but in this act, the inflated lungs always follow closely contiguous to the pleura, without leaving any intermediate space. At the same time the pulmonary blood-vessels, which are wrapped up, together with the bronchia, in a covering of the cellular substance, are likewise with them extended in length, and spread out from smaller into larger angles, by which means the circulation is rendered easier through them. While this is performing, the vesicular substance, or flesh of the lungs themselves, filled out with air, increases those spaces through which the capillary blood-vessels of the lungs make their progress, whereby the vesicular pressure, upon each other, and upon those vessels adjacent, is lessened; thus, therefore, the blood will flow with greater ease and celerity into and through the larger and smaller vessels of the lungs. Hence, we observe, the pulse is quicker, during the time of inspiration. But as for the pressure of the air upon the blood in the lungs in this action, it is so inconsiderable, as not to deserve our notice. [For the pressure of the atmosphere is never naturally so much increased, as to urge the air through the pores
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of the lungs into the blood, as it easily may be forced by art with a syringe; although some of the air may be substantially expelled or absorbed this way, as it is in common, through the pores of all other bodies, while it approaches to a solid or fixed state.]

§. 293. It is by some queried, whether there be not air betwixt the lungs and the thorax? and whether this air, being rarefied in inspiration, is not afterwards condensed, so as to compress the lungs, and cause inspiration? and they again ask, whether this opinion be not confirmed by the instances of birds, in which we find this matter to be truly so. But we see every thing concurs to confute this opinion: for (1.) immediately behind the pleura, in living quadrupeds, as well as in dead human bodies, the lungs are contiguously visible to the naked eye, without any intermediate space betwixt them (§. 290.); but the pleura being perforated, the lungs are immediately, by the contiguous air that enters, pressed together towards the vertebræ. (2.) Large wounds, admitting the air only into one cavity of the thorax, diminish the respiration; but such wounds, as let the air into both cavities, quite suffocate or suppress the respiration. (3.) The thorax being opened under water, sends out no bubbles of air through the said water. Again, (4.) the imaginable space betwixt the lungs and the thorax is always filled up by a watry or serous vapour, or else, by the same vapour, condensed into a watry lymph. (5.) If the lungs adhere, they injure the respiration but in a small degree;

gree; which ought entirely to cease, if it required an intermediate air betwixt the lungs and thorax. Finally, (6.) the external air, being admitted to any of the internal membranes of the human body, destroys their texture, if they are not defended by a plentiful mucus; of which we can find none, either upon the surface of the lungs or of the pleura.

§. 294. After the thorax has been every way dilated by the said powers (§. 290, 286.), as far as it well can be, or as far as is sufficient for the purposes of life and health, the air, thus received into a place constantly near thirty degrees hotter than itself, grows warm there from the blood, [for the middle degree of the air's heat, in the northern countries of Europe, mounts the thermometer to about 48 gr. while the mean heat of the expired air from the lungs is 94 gr. of which the difference 46 gr. of heat is gained by the air from the blood, since breath seems to have the same heat with the lungs in its contact] from which it acquires about fifteen degrees of heat; therefore the air thus expanding the cells to their utmost extent, whose dilatation, at the same time, meets with no empty space in the thorax, the blood thereupon begins to be stopt by the air's expansion [being rarefied or increased one twelfth part of its bulk] compressing the least vessels, by which means a new resistance arises to the blood, perpetually flowing from the heart into the lungs; and, therefore, we see, in hard straining and long retentions of the breath, the venal blood stagnates in the veins (especially
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about the head) before the right side of the heart, which is now shut, because unable to empty itself into the lungs; whereupon the face swells or looks red, and sometimes the veins of the brain, neck, intestines, kidneys, lungs, or even the right auricle itself, will be burstened by the violence. Such is the cause of death, in those who are suffocated by compressed air, by drowning in water, or by strangling with cords. Therefore that anguish or uneasiness, which arises from the stoppage of the blood in its course through the lungs of a healthy person, is the occasion which excites him to open or relax again the powers of inspiration, and immediately to stir up the forces which concur to expiration, thereby to free the thorax and lungs from the too much rarefied air.

§. 295. The powers concerned in expiration are chiefly the oblique muscles of the abdomen, together with the strait and transverse ones. The former of these are, in one part of them, fastened to the lower ribs, and, in another part, they are attached to the os pubis and ilium, as a fixed point, with respect to the breast. Therefore the strait muscles, being contracted, depress the arch or convexity into which the abdominal viscera are thrust by the diaphragm, and bring the same nearer to a strait line; and, at the same time, the abdominal viscera are pressed by those muscles upward and backward against the diaphragm, which alone is able to give way, and yield up into the thorax, which, at that time, is rendered shorter. The oblique muscles, for the same reasons,
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compress the lateral parts of the abdomen, and urge the liver, spleen and stomach upwards: and lastly, they draw down the ribs, which were before elevated by the intercostals. The transverse muscles, indeed, do not draw down the ribs, but they pull the cartilages of the false ribs a little inward, and render the whole capacity of the abdomen less, while, at the same time, they urge the viscera against the diaphragm. By these means the thorax, contrary to its former state (§. 286.) is every way rendered narrower and shorter, so as to expel as much air out of the lungs, as is sufficient to relieve the uneasiness caus'd by its retention (§. 294.). At the same time the muscular fabric of the bronchia exerts a power of contraction against the distending air, so as to promote its expulsion; and the ribs themselves likewise returning by their elasticity to that situation and rest, which their articulations require in a state of expiration, do all of them fly upwards and together, so soon as the extending powers cease; whereupon their elasticity restores them spontaneously to their respective places during expiration. From hence expiration becomes easier than inspiration, and quicker in proportion as three to two; and from hence it remains always as the last act in a dying person. The triangular muscle also of the sternum, by elevating the cartilages of the true ribs, together with the sternum itself, which they draw upward and backward, has some small share in this action.

§. 296. In a more powerful respiration, when the inspirations are made wilfully greater, the expirations are likewise increased by the assistance of some other powers, as of the sacro lumbalis, longissimus and quadratus muscles of the back and loins. This force, by which the air is blown out of the lungs through a tube, is sufficient to carry a leaden bullet, weighing above a dram, to the distance of one hundred and sixty yards. But in a healthy person, the muscles of the abdomen alone suffice to an easy expiration, in which the lungs are not so much emptied of air as they are by a violent efflation.

§. 297. The effects of expiration are a compression of the blood vessels in the lungs, a reduction of the bronchia or branches of the wind-artery into more acute angles, a pressure of the reticular small vessels by the weight and contact of the adjacent larger vessels; by which means part of the blood, hesitating in the capillary arteries, is urged forward through the veins to the left side of the heart, while, at the same time, that part of the blood is resisted which flows in by the artery from the right ventricle; for we see, by experiment, that if the lungs are not inflated, they are never well filled by an injection, which always succeeds the best, by causing the lungs to imitate vital respiration. [Does not, therefore, the blood seem to flow quicker through the lungs, than through other parts of the body? and is not this made probable from the quantity of the blood,

blood, and the shortness of its course, in going from the right to the left ventricle?]

§. 298. In this manner a fresh necessity follows for repeating the respiration; because the collapsed vessels of the lungs resist the blood, repeatedly expelled from the right ventricle of the heart. And this makes another cause of death, in those animals which expire in vessels exhausted of air: for in such, the lungs, having the air drawn out from them, appear dense, solid and heavier than water; whence they are rendered impervious to the blood. Of the same kind is the death of those who are extinguished by lightening. Thus, therefore, by the power of a most wise fabricature, the organs of expiration are relaxed, so soon as that uneasiness is perceived, which arises from the hinderance of the blood's course through the lungs; and thereupon the powers of inspiration are excited into action, whereby the course of the blood through the lungs is rendered free and quicker. [A dense air will support life much longer than that which is rarified; because the former more easily and spontaneously enters and distends the lungs, while the latter, being unable to overcome the resistance of the air-vessels and confined breath, is excluded. Yet a healthy person can, without much difficulty, support any air that has but half the common density of the atmosphere.]

§. 299. It is by some queried, whether or no there are not other causes of alternate respiration? whether or no we may hope for any discovery in this matter, by compressing the

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vena azygos, the phrenic nerve, or intercepting the blood sent to the brains? But those are repugnant to comparative anatomy; by which we always find the same alternation in the breathing of the animal, independent of any such nerve or vein. Whether or no respiration is from the alternate contraction of the antagonist muscles, among which, those of expiration relax the others of inspiration, and the reverse? but in this manner, all the muscles of the human body are perpetually in an alternative motion.

§. 300. From what has been hitherto said, it appears, that respiration is unavoidably and absolutely necessary to life in a healthy adult person; because, whether the lungs remain long in a state either of expiration or inspiration (§. 298, 293.), we see death will be the consequence. Therefore no animal, that has lungs like ourselves, after it has once breathed, can subsist longer than a few minutes without the use and benefit of a free air; but it will either perish, or, at least fall into such a state, as differs from death only in its being recoverable again by certain powers or actions.

§. 301. But the use of respiration is different from this necessity, which nature might have avoided, either by using no lungs at all, or else by disposing them in a manner, resembling those of the foetus. This use, therefore, of respiration must be very considerable, since all animals are either made with lungs, or with gills as in fish, or else with a wind-pipe diversified

perfed through all parts of the body, as in infects.

§. 302. In order to difcover this immediate ufe of refpiration in mankind, let us compare the blood of an adult perfon to that of a foetus, and alfo with the fame vital fluid in fifh. It appears then in a foetus, that the blood is deftitute of its florid rednefs and folid density; and in the blood of fifh we obferve, there is neither heat nor density, and but little craffamentum contained in it; and, therefore, all thefe properties, we are, by the nature of things, perfuaded, the blood acquires in the lungs.

§. 303. It follows, therefore, that our blood acquires its heat principally in the lungs; for that all animals, which have lungs, and two ventricles in the heart, have the heat of their blood commonly twice that of the atmofphere (§. 294.). [Thus, in the fame northern feas, we obferve, that thofe fifh, which have no lungs for breathing, are cold as the element, although their flight and motion through the waters be ever fo ftrong and rapid; but at the fame time thofe of the whale kind, which breathe with lungs, have their blood warm like that of man, although they remain almoft ever fleepy and fluggifh. Neither the heart, therefore, nor all the reft of the body, are able to generate the heat of the blood, without the affiftance of the lungs.] But does not this arife from the alternate extenfion and contraction, relaxation and compreffion of the pulmonary veffels (§. 292, 295.), by which the folid

parts of the blood are perpetually rubbed together, and closely compressed in the attrition that is made during expiration, as it is more rapidly moved and ground together during inspiration. Nor is it any objection to this, that water cannot be made to grow hot by any friction. Nor, in reality, is that assertion true; for water, by violent winds and motion, as well as milk, acquires some degree of warmth; and the blood, which is so much more elastic and inflammable than water, must of course acquire a much greater heat. Nor is the heat of the blood from any effervescence. For only the muscular motion, being increased, or even merely by an increased use of the organs of respiration, the heat of the blood is augmented; as it is diminished in proportion, as those actions are diminished, and soon ceases when they are wholly suppressed.

§. 304. The density of the blood is, indeed, again promoted in the lungs, partly by the copious discharge of the watry vapour, which is there separated, and expelled from the pulmonary vessels, by which the rest of the mass will become specifically heavier. But the same effect seems to follow more especially from the attrition and pressure, which the blood here suffers in being alternately retarded, accelerated, and figured in its course through the modulating tubes of the least vessels, which give a sphericity and density to the particles. And, in this respect, the pulmonary vein, being smaller than its corresponding artery, is of no small use towards increasing the attraction of cohesion

sion betwixt the parts of the globules, so as to compress and bring them closer to each other. But it is well known, by the experiments of Sir Isaac Newton, that redness is increased by a greater density of particles. From hence it is, that the redness, heat and density of the blood are always proportionably encreased together by muscular motion or exercise, with which the motion of the lungs in respiration necessarily corresponds and increases. [But that there is some small difference betwixt the blood of the lungs and that of other parts, is argued from many experiments; and particularly extreme cold there condenses the blood in some degree. Add to this its difference from the thin, watry and light blood of fishes.]

§. 305. It is, therefore, queried by some, whether the air itself is not received by the blood in the lungs, so as to excite necessary vibrations therein? whether this does not appear from the resistance of bodies to the heavy external air; and from the air found in the blood vessels, in the cellular substance, and in certain cavities of the human body; also, from the cracking observed by an extension of the joints; to which add the air manifestly extravasated from the wind-pipes into the hearts of certain animals, as in the locust, together with a necessity of a vital oscillation in the blood itself? [and lastly, the increased redness of the pulmonary blood?]

§. 306. Contrary to all this, it is evident, that the blood here receives no air into itself;

partly from the minuteness of the inhaling vessels, with the mucus that perpetually lines the sides of the vesicles in the lungs; to which add the nature of the elastic air itself, which is very unapt to pass through capillary vessels, with a repulsion of it by water, that hinders it from passing through paper, linnen cloth or skins that are wetted by water. Again the air being drove into the wind-pipe, never passes to the heart, or whenever it does, it is forced thither by some great or unnatural violence: but the permanent air in the vessels and humours of the human body, from a state of inelasticity, may become elastic by putrefaction, frost or an external vacuum. But such permanent unelastic air is incorporated with all liquors, and taken into our bodies with the aliments and with absorbed vapours, mixing slowly and with some difficulty. But there never were any elastic bubbles of air observed in the blood of a living animal; and such air, being inflated into the blood vessels of any living animal, kills it certainly and speedily. [Nor is there any great certainty of the blood in the pulmonary veins, being of a brighter red colour.]

§. 307. Whether or no the blood is cooled in the lungs? and whether or no this seems to be true from the death of animals in air, which is hot to such a degree, as equals the heat of the hottest breezes in the most sultry dog-days? [and whether the pulmonary veins are not, therefore, less than the arteries?] that the blood is cooled in the lungs, is thus far true;
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in that, it there communicates fifteen degrees of its warmth to the contiguous air (§. 294.). But that this was not the principal design of nature here, upon the blood, is evident; since no one will say, that the venal blood is hotter than the arterial, although some pronounce the former to be somewhat cooler. Since, therefore, the venal blood enters the lungs, if it be there cold, it will follow, that the arteries must receive it still colder. But then here the degrees of heat, which the blood communicated to the air, are again recovered by it. [And, indeed, a person may live in an air much hotter than the blood itself. We see the greater capacity of the right ventricle and pulmonary artery was necessary to reserve and retard the blood, as the pulmonary vein, being narrower, accelerates it.

§. 308. Whether the use of the lungs is to absorb a nitre from the air to the blood? or whether the florid colour, observable in the surface of a cake of blood, be owing to the same cause, while the bottom part looks of a dark and blackish colour? remain as questions with some. That there is a kind of volatile acid in the air is certain, since that meeting with a suitable earth forms nitre; for a nitrous earth, being exhausted of its salt, and exposed again to the air, becomes re-impregnated with more nitre. But the same universal acid, we know by certain experiments, meeting with a different sort of earth, forms a vitriolic salt, or else sea-salt. For the caput mortuum of sea-salt,

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which



which remains after the distillation of the spirit, recovers so much strength from the air, as enables it to yield more spirit by distillation; even in snow there is a cubical salt, but marcasite sweats out a true vitriol, and colcothar recovers again the acid spirit, which was drawn from it; also fixed alkali, exposed to the air, turns into a vitriolic tartar. This, therefore, cannot be the use of respiration, because those salts abound in too small a quantity in the air for such uses; and air is fittest for breathing when pure in high mountains, where those salts are the least to be found; nor is there any nitrous salt, as yet known, to be found in our blood. As for the upper part of the surface of the cake of blood appearing of a bright florid colour, that arises from a relaxation or looser disposition of the spherical globules there, while the bottom part appears black, because the globules are there more compressed and condensed by the other incumbent parts.

§. 309. If it be asked, why tortoises, frogs, lizards, snails, ear-wigs and other insects live long without air; we answer, that in them the lungs are given not so much for the preparation of the blood, which they receive but in a very small quantity, as for the use of swimming in the water: and from hence it is that their lungs are immediately joined with the vena cava and great artery. But insects, we know, draw the air in, and exhale it again through their skin. If it be asked, why all animals perish in air that is confined or not renewed,

renewed, although the animal be small, such as little birds; we answer, because the air, which has once entered the lungs, and been fouled by watry vapours, is rendered less elastic, and unfit for respiration by alkaline vapours. Hence it is, that the animal survives longer in air that is more compressed, than that of the atmosphere: for in that case, there is a greater proportion of the elastic element, which takes up a longer time to corrupt it. But even, in other cases, confined air is rendered destructive only by stagnation, and filling it with vapours. But the reason, why animals swell in an exhausted vessel, is, from the extrication and expansion of the unelastic air lodged in the blood and other juices.

§. 310. There is a certain consent or proportion between the pulse and the respiration; that according to the common course of nature, there are three or four pulses counted to one respiration. But if more blood is sent to the heart, in a given time, the numbers, both of the pulse and respiration, are increased. This is the reason of the panting or short breathing in a person that exercises his body with any considerable motion; whereby the venal blood is returned faster to the heart (§. 142.). But if the blood meets with a greater resistance in the lungs, so that it cannot pass freely from the right into the left ventricle of the heart, then the respiration is increased both in the number and magnitude to forward its course; and this is the cause of sighing and yawning. If it be asked,

asked, why an animal that is dying may be recovered again to life, by inflating air into the lungs; we answer, that the proximate cause of death (§. 257.) is too great a resistance opposed to the course of the blood through the lungs, whereby it cannot pass to the aorta; but, by inflating the lungs, that resistance is removed, and the way opened for the blood to pass on, (§. 286.).

§. 311. The mucus, which lines the sensible membranes of the air-vessels in the lungs, may become troublesome, both by its quantity and acrimony; it has been even known to cause suffocation in a dropsy of the lungs. Therefore its quantity, adhesion or acrimony excites a cough; namely, an irritation of the respirative system, by alternate large inspirations, succeeded by large and quick expirations, together with sudden shocks of the abdominal muscles, by which the mucus, and sometimes calculous matters are expelled from the lungs.

§. 312. Laughter differs from coughing in its cause, which resides commonly in the mind, or, at least, consists in a certain titillation of some of the cutaneous nerves; and, moreover, because it is made up of imperfect quick expirations through the contracted glottis, after one large or deep inspiration; nor is the air perfectly evacuated from the lungs in laughter, which, in a moderate degree, conduces to health, because to one full inspiration are joined many shaking expirations, agitating the blood.
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But much of it is in danger of stagnating the blood, because the expiration is not full or entire, whereby the blood is admitted into the pulmonary artery without being suffered to pass through it. Weeping has short respirations like those of laughter, but finishes with a deep expiration that is immediately joined by a large inspiration; whence it has nearly the same good and bad effects; and, when moderate, it conduces to relieve the anguish arising from grief. Sneezing consists of one large or deep inspiration, which is followed immediately with a powerful and sudden expiration.

§. 313. The additional or secondary uses of respiration are many. [It exhales, as an emunctory, parts redundant, or even noxious from the blood, which, in confined air, suffocates.] It is by this force, that the abdomen, with all its viscera, are continually compressed; by virtue of this, the stomach, intestines, gall-bladder, receptacle of the chyle, bladder of urine, intestinum rectum, and the womb itself, discharge their contents; by this action the aliments are principally ground or dissolved, and the blood is urged thro' the sluggish vessels of the liver, spleen and mesentery. Moreover, inspiration serves to convey odours with the air to the organs of smelling. By this, the air is mixed with the aliments, which it conduces very much to break and dissolve towards a perfect digestion. But even sucking, so necessary and natural to the new-born infant, is made by the use of respiration, and forming

ing an ample space in the mouth, in which the air is rarefied, so that, by the greater pressure of the outward air, the milk is drove into that part where it is less resisted. Lastly, the voice itself is owing to the air which we breathe; therefore it may be not inconvenient for us, in this place, to describe it more particularly.



LECTURE XI.

Of the voice and speech.

§. 312. **T**HE principal organ of the voice is the *larynx*; for that being injured, the air passes through the wind-pipe without yielding any sound. By the larynx, we understand an assemblage of cartilages, joined into a hollow machine or pipe, which receives the air from the fauces, and transmits it into the wind-pipe, having its parts connected together by ligaments and muscular fibres. Among these cartilages of the larger kind, those, called the anular and scutiform, are, in adults, frequently changed into bone. The anterior and larger part of this larynx, which lies almost immediately next to the skin, is composed of two cartilages, one called *thyreoides*, the other *cricoides*; to which last the lateral parts of the larynx are so joined, that the portions are always so much larger, as they are higher seated. The back part of the larynx is first made up by the said anular cartilage, after connected by the ary-tænoide muscles. The epiglottis is loosely connected above the larynx with the thyreoid cartilage, in such a manner, that it may be able to rise up and shut down. The blood vessels of this part are from the upper thyreoids; and the nerves, below, are numerous from the recurren-
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the eighth pair variously inosculating. The former of these nerves is remarkably famous for its arising in the thorax, and being afterwards inflected round the aorta and right subclavian; and for the origin, which it gives to some of the nerves of the heart, as well as for the experiment, by which a ligature upon the recurrent is found to render the voice insonorous.

§. 313. All these cartilages are connected together by various muscles and ligaments, with a certain degree of firmness to the adjacent parts; and yet so, that the whole is easily moveable together, as are also its several parts upon each other. Particularly the *scutiform* cartilage, or the thyroidea anterior, composed of two plates, which are almost quadrangular, are inclined to each other in an obtuse angle, which is foremost. Upon these cartilaginous plates, are sometimes found two apertures, one on each side for the blood vessels of the larynx; but are not very often to be observed. The upper processes of this cartilage, terminating without any protuberance, are inclined upward and backward to their connection with the horns of the os hyoides by strong ligaments. The lower parts of these cartilages are shorter, and adapted almost with a flat surface to those of the cricoide cartilage, to which they are connected with a very firm articulation, by a strong and short cellular substance, uniting them on each side. The middle parts before, being perforated with strong ligaments, are connected by the insertion of them to the middle of the anular cartilage; and likewise by
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other ligaments above, descending from the horn of the scutiform cartilage into the upper part of the anular cartilage.

§. 314. The cricoide cartilage is before thick, and strong increased backward; 'tis in form of a ring unequally truncated or cut through, and in its middle part is divided into two cavities by a protuberant line. This is firmer than the rest of the cartilages, and, in a manner, the foundation of them; from this there are longitudinal muscular fibres and ligaments, which descend into the wind-pipe (§. 266.). The pharynx likewise is connected to the surface of these cartilages by many muscular plates, and receives the larynx as it were into its bag.

§. 315. The two arytaenoide cartilages are of a very complex figure, spontaneously dividing into two parts; of which the lower is larger, and is connected by a moveable juncture with the protuberant cricoide cartilage, by a basis moderately hollow. They ascend upwards, of a triangular figure, with the posterior angle hollow, the anterior convex, divided by three furrows or sulci, and extenuated upwards, 'till they are, at last, finished or terminated by a pretty thick, oval, cartilaginous head fixed on them. The lower part of these cartilages are connected by numerous muscular fibres, partly transverse and partly oblique, of which the different directions are visible enough, but the separation of them impracticable. These are called arytaenoide muscles. In the upper part the arytaenoide cartilage departs from its companion or fellow cartilage, leaving a rima or cleft

cleft perpendicularly betwixt them, which has been (not very properly) by some called the glottis.

§. 316. The arytænoide cartilages are connected with the thyreoideals, by transverse ligaments sufficiently strong and elastic, but covered with the common mucous membrane of the larynx, which ligaments are inserted into the flat angle of the thyroide cartilage (§. 313.) These ligaments may be drawn out or stretched from each other by removing the contact of their arytænoide cartilages, and may be again conjoined together by placing the cartilages one to another; and this is the true glottis, which is continuous with the said rima (§. 315.), but at a right angle.

§. 317. From the same angle of the thyroide cartilage, under a notch, from a firm ligament is extended backwards a hollow, and somewhat oval cartilage, in its fore-part convex, behind concave, and raised up in such a manner, by its elasticity, as to project considerably behind the tongue; but is so flexible or inclinable downward, whenever the root of the tongue is pressed backward, that, by its transverse position, it shuts up all passage into the larynx, and defends it in such a manner, that whatever is contained betwixt this part, called the epiglottis, and the arytænoide cartilages, passes over downward into the pharynx. The epiglottis is conjoined to the tongue by pale membranous fibres, and to the os hyioides it is connected by many membranous expansions. But as for muscular fibres from the thyreo-arytænoidal

tænoidal muscles and from the ary-arytænoidal muscles, it has either none at all, or else such as are too minute to have any effect upon its elasticity.

§. 318. By the sides of the ligaments of the glottis (§. 316.), there are two other upper and softer ligaments, which go out parallel from the arytænoide cartilage to the scutiform one, which ligaments are somewhat less tendinous and less elastic. Betwixt these two ligaments, on each side (§. 318, 316.) a peculiar cavity or ventricle descends, having the figure of a compressed parabolic sinus extended downward betwixt the double membrane of the larynx, opening constantly with an elliptical mouth by the side of the glottis in the larynx.

§. 319. Lastly, all the internal cavity of the larynx is lined with the same soft sensible or irritable and mucous membrane, as we before described in the wind-pipe (§. 263.). But this membrane is watered by a great number of small glands here situated. The uppermost are small simple glands, assembled together in a heap (§. 201.) seated on the anterior and convex part of the epiglottis, upon the hollow surface of which they send out various openings, small sinusses, and productions; and others are, in like manner, continued there in small hard acini or bunches. Moreover, upon the hollow anterior surface and back of the arytænoide cartilages (§. 315.), there are small glandules placed on each side of a loose conglomerate fabric, composed of little round acini or heaps, almost of a triangular shape, and are, doubt-
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less, muciferous, having some of their looser parts extended on each side as low as the annular cartilage. In the cavity of the ventricles, there are many small mucous glandules; and lastly, all the internal surface of the larynx is full of large mucous pores. All these glandules separate a thin watry mucus, which yet has a considerable degree of visciduity.

§. 320 Perhaps the thyroide glandule has a like use. It is of the conglomerate kind, but soft and lobular, with many coverings considerably large or broad in its extent, but of a more tender substance than the salival glands, seated upon the thyroide cartilage, and in part upon the cricoide cartilage and wind-pipe, along their fore part, so as to encompass the lateral horns and sides of the thyroides; but ascending upwards by a very thin process before, in its middle part, as far as the os hyoides. This gland is full of a serous, yellowish, and somewhat viscid humour; but whether it emits the same into the wind-pipe or into the gula, is not yet determined; at least, there are no ducts certainly known to open into either of them. Whether or no the juices are altogether retained in this gland, and afterwards poured into the veins, in a manner resembling the fabric of the thymus, or whether it is of the conglobate or lymphatic kind, is uncertain. Yet, that the use of this gland is very considerable, may appear from the largeness of the arteries, which it receives from the carotids and lower subclavians. The veins thereof return their blood into the jugulars and subclavians. It has
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peculiar muscle, not constantly to be found, arising from the edge of the os hyoides, and sometimes from the lower margin to the left of the thyroide cartilage, which descends without a fellow, spreading its tendinous fibres over the gland. Upon which also the sternohyoidei and sternothyroidei muscles are likewise spread or incumbent.

§. 321. The whole larynx, together with the conjoined os hyoides, is capable of being raised considerably, at least half an inch above its mean altitude; which elevation is performed by the biventer muscles, together with the geniohyoidei, genioglossi, styloglossi, stylohyoidei, stylopharyngei, thyreopalatini, hyothyroidei; all or some of which conspire together in that action. In this elevation the glottis is pressed together or made narrower, and the ligaments before-mentioned (§. 316.) approach nearer together. But thus, by the assistance of the action of the arytænoide muscles, together with the oblique and transverse ones, the glottis may be accurately closed, so as to resist with an incredible force the pressure of the whole atmosphere.

§. 322. The same larynx may be, in like manner, depressed to about half an inch beneath its ordinary situation by the sternohyoidei, sternothyroidei, and caracohyoidei, as they are called; and, when these are in action, also by the joint force of the anterior and posterior cricothyroidei. In this motion the arytænoide cartilages depart from each other, and render the glottis wider, which is also drawn open laterally by the muscles inserted into the sides

of the arytaenoid cartilages, together with the cricoarytaenoidi postici and laterales. The thyreo-arytaenoidi, incumbent on these parts, may compress the ventricles of the larynx (§. 318.).

§. 323. Hitherto we have given the anatomy of these parts, It remains, therefore, that we demonstrate what action the air produces, when it is driven by the foresaid powers (§. 295.) from the lungs in expiration through the wind-pipe into the larynx, and from them urged out through the glottis into the mouth variously configured. The consequences or effects of this, are voice, speech and singing. And first, the voice alone is formed, when the air is expelled with so great a velocity thro' the contracted glottis, that it splits or makes a collision upon the glottid ligaments, so as to put the larynx into a tremor, which tremor is returned and continued or increased by the elasticity of these parts. Sound, therefore, arises from the conjunct trembling of the ligaments (§. 316.), together with the cartilages of the larynx at one and the same time, which we then call the voice, and is of a peculiar kind or modulation in every single class of animals, depending entirely upon the difference of the larynx and glottis. But when a trembling is not excited, the expired air causes a whisper.

§. 324. The strength of the voice is proportionable to the quantity of air blown through the glottis; and, therefore, a large pair of lungs, easily dilatable with an ample larynx and wind-pipe, joined with a powerful expiration,

tion, all conduce to this effect. But acute and grave tones of the voice, we observe to arise from various causes, The former proceeds from a tension and narrowness of the glottis, and the latter from a relaxation and expansion of it. For thus, in the former, a greater number of air-waves are split in the same time upon the ligaments of the glottis, whence the tremors, excited at the same time, are more numerous; but when the glottis is dilated, the contrary of all this follows. Therefore to produce an acute and shrill voice, the larynx is drawn up more powerfully, as the voice is required to be sharper, insomuch that an inclination of the head forward is called in to assist, by which the powers of the muscles, elevating the larynx, are rendered more full and effectual. The truth of this is confirmed by experience, by applying the fingers to the larynx when it forms an acute sound; for then to raise the voice an octave, you will easily perceive it to ascend near half an inch: also the same is evident from comparative anatomy, which demonstrates the narrowest glottis and the closest approximation of cartilages in canorous birds; but an ample or broad glottis in hoarse animals and such as bellow or bleat; an instance of this we have in whistling, where the voice manifestly becomes more acute by a contraction or narrowness at the mouth: and likewise also in musical instruments, in which a narrowness of the mouth or opening that expels the air, with a celerity of the wind blown out, are the causes of an acute or shrill tone.

§. 325. Gravity of the voice, on the contrary, follows from a depression of the larynx by the causes (§. 323.) already described; to which add a broad glottis and a very ample larynx. This is evident to the touch of the finger applied to the larynx, when a person sings, by which the descent of it is manifestly perceived to be about half an inch for every octave; hence the voice of males is more grave; and hence the lowest degrees of the voice degenerate into a muteness or whispering.

§. 326. Singing is when the voice, modulated through various degrees of acuteness and gravity, is expelled thro' the larynx, while it is trembling and suspended betwixt two contrary powers; and herein lies the principal difference betwixt the chanting of simple notes, and the expression of words. Hence it appears to be a laborious action, by reason of the continual contractions of the muscles, which keep the larynx at an equilibrium; and hence it is, that singing makes a person hot, because in acute tones the narrower glottis much retards the expiration, while, at the same time, a great deal of air is required to give strength to the voice (§. 324.); towards which again deep inspirations are necessary. Hence likewise the wind-pipe is rendered very dry, from the quicker passage or current of air, to prevent which a great deal of mucus is required; and, therefore, it is, that there are such numbers of mucous receptacles in the larynx, amongst which, I am firmly of opinion, the ventricles before described (§. 318.) ought to be numbered.

§. 327.

§. 327. Speech is performed by the larynx at rest, or held in the same place, in tones of voice differing but little in acuteness and gravity; but then the voice is variously changed or modulated by the organs of the mouth. Canorous speech has a variation in the tone or cadence of the voice, together with a modulation of it by the organs of the mouth at the same time.

§. 328. All speech is reducible to the pronunciation of letters, which differ in various nations; but most of them are alike all the world over. Of these, some are called vowels, which are made only by an expression of the voice through the mouth, without any application of the tongue to certain parts of the mouth. But consonants are formed by a collision of the tongue against certain parts of the mouth, lips and teeth. But to be more particular in these matters is besides our purpose, which will not permit us to expatiate upon the beautiful art of pronunciation. That art, as an extraordinary instance of mechanical knowledge, has so accurately determined all the corporeal causes concurring to each letter, that, by inspection only, with the assistance of touch, letters pronounced are understood without hearing them, and the attentive person is thereby taught to imitate the same speech by a like use of the organs.

§. 329. Whether or no all the difference of tone in the voice depends entirely upon the length of the ligaments of the glottis, increased by the scutiform cartilage drawn forward, and the

arytænoide cartilage drawn backward, in such a manner, that the sharpest are those made by the ligaments in the greatest tension, and, therefore, with a quicker vibration? this had been advanced by the experiments of some gentlemen of note, and since repeated by other anatomists, [who judge, that the tense chords or ligaments of the glottis do, from the air perflated by the wind-pipe, produce the voice and its several tones in animals; so that greater tensity and closure of the ligaments yields a more acute voice, as a laxity of them occasions a more grave tone of the voice. That those ligaments, drawn close, suppress the voice; or being half way shut, and the rest open, they give a tone that is one octave higher; as a third part of them, thus shut, yeilds a fifth higher, &c.] I shall not take upon me to determine in a matter of such importance, that has not yet fallen under my examination experimentally; there are considerable doubts or objections to be made against this system, taken from the cartilaginous and bony glottis, which is thus immoveable, and in no ways extensible in birds; also from the voice becoming infallibly more acute in whistling, merely by a contraction of the lips only; also from the instance of women, who having a shorter larynx and glottis than men, nevertheless utter a more shrill voice; likewise from the experiment, by which it appears, that the tone becomes more acute by approximating the ligaments of the glottis nearer together; again, from the doubtfulness of the credit upon which those new experi-

experiments are published ; from the want of a machine of any perfection to draw the scutiform cartilage forward ; and lastly, from a strong and evident suspicion, that the author of the experiment imagined the scutiform cartilage to be drawn forward, when it was, in truth, only elevated. Therefore this invention merits further enquiry ; and as the author's laudable endeavours are not to be here discouraged by a refutation, so neither are they to be hastily embraced with too much credulity.



LECTURE XII.

Of the brain.

§. 330. **T**HE remaining actions of the human body, we shall consider according to the order by which they receive the blood from the arteries. The coronary arteries, we spoke of before, when we gave the history of the heart; but next to those, the carotid arteries pass out from the aorta.

§. 331. The aorta, which comes out from the anterior part of the heart (§. 128.), in order to bend itself towards the vertebræ of the thorax, forms there a considerable arch, by which it is bent backward, and towards the left, in angle that is round but not very large. From the convexity of this arch, three considerable branches arise, of which the first ascends towards the right side, and is immediately subdivided into two large arteries. The lowermost goes on in the direction of its trunk, under the denomination of the subclavian. The other ascends according to the course of the wind-pipe to the head, and is called the *right carotid*. The *left* carotid springs next, a little inclined from the same arch further to the left side; and the third, which is still more inclined to that side, is called the left subclavian, which is something less than the right. About the origination of these arteries, the next continuous margin of the aorta is a little thicker:

thicker and more protuberant. [But variations from this course are observed rarely.]

§. 33. The carotid artery commonly ascends as high as the thyreoide cartilage, without sending off any branches, wrapped up together with the jugular vein and nerve of the eighth pair, in a thick, dense, cellular substance. There, at the said cartilage, it divides into two trunks, one anterior, called the *external* carotid, which is rather larger and more in the direction of its trunk; and this constantly sends off a branch called *thyreoidea*, superior to the gland of the same name, to the gula, to the posterior and anterior muscles of the larynx. This branch sometimes arises also below the division of the carotid. The same external carotid sends off from its inner side, the inflected arteria *lingualis*, and then the *labialis*, which, having given branches to the tonsils, moveable palate and uvula, ascends in a serpentine course over the face to the termination at the nose, and communicates by anastomosis with the ophthalmic artery, and with its fellow artery on the other side. From the posterior face of the carotid, the next artery which arises, is the pharyngea ascendens, which, besides the pharyngea and branches to the muscles of the moveable palate, sends likewise a considerable branch in common with the nerve of the eighth pair through the foramen of the jugular vein to the dura mater, very near to the great foramen of the occiput, and by the os petrosum; afterwards this artery divides
itself

itself at the cuneiform process of the multi-form bone.

§. 333. Again, from the outer edge of the external carotid, springs the *occipital* artery, which sends branches not only to the muscles, which give it a name, but likewise sends a branch through a peculiar foramen of the dura mater in the angle, which the os petrosum forms by departing from the mamillary process, which artery is spread through the seat of the cerebellum ; another branch passes over the atlas to the dura mater under or into the skull ; and a third sometimes goes through the fossa jugularis to the dura mater. The next artery, which is the *auricularis*, goes to the back part of the ear, to the temple, and to the membrane of the tympanum.

§. 334. What remains of the external carotid artery, ascends through the parotid gland, to which, having given some branches as well as to the face and eye-lids, it sends out the *temporalis*, which is a considerable superficial artery upon the integuments of the bones of the temples and forehead. The trunk of the carotid, being inclined, conceals itself behind the lower jaw, under the denomination of *maxillaris interna*.

§. 335. In that place, it directly sends off a large trunk, which passes to the dura mater through a peculiar opening of the broad and pteryoide wings, seated at the middle fossa of the brain ; from whence they are largely spread through the temples and forehead within the dura mater, as far as the falciform sinus. Sometimes

times this artery is double, and often gives out a branch, that is conspicuous to the lachrymal gland of the eye. In the same place likewise, the maxillary artery enters in, under the root of the wings through the sphenomaxillary fissure; whence ascending, it passes by a three-fold trunk as far as the upper part of the nares, where it is spent, after having given off the branches called maxillaris inferior, and the superior to the teeth, with the infra orbitalis, to part of the face and eye-lids, and the palatina to the bone of the palate, with small branches to the dura mater, and others through the smaller pores of the great wings, with such as accompany the third and second branch of the fifth pair of nerves; and lastly, together with the dura mater filling up the lower orbital fissure.

§. 336. But the other posterior trunk, commonly called the *internal carotid* (§. 332.) ascends without a branch. This artery, having first made a considerable serpentine flexure, enters through a peculiar foramen in the os petrosum, where it is surrounded with a capsule from the dura mater, like that which comes out through all the openings of the skull; from thence it ascends upwards and inclined forwards, 'till, having penetrated into the cavity of the skull, it rises up inflected and in a curvature, according to the direction of the sella equina, in the middle of which, there is a cavernus or hollow sinus, retarding the blood; from thence, having given small branches to the fifth pair of nerves, it sends others to the infundibilum and dura mater, with one larger to the eye, part
whereof

whereof returns again through a peculiar hole into the dura mater, which lies upon the middle of the orbit.

§. 337. But the trunk of this internal carotid, passing over the anterior part of the sella equina, is incurvated backward, and being received by the arachnoide membrane, giving branches to the pons and crura of the brain, with a circle to the choroide plexus, and one that accompanies the optic nerve, it then divides into an anterior and posterior branch. The former, being conjoined with its fellow artery of the other side by a short inosculating branch, which sometimes springs from the trunk itself, is then incurvated backward and upward, according to the direction of the os callosum, and spreads itself about the middle part of the brain. The latter or posterior division of the carotid, being conjoined by a small inosculating branch with the vertebral artery, afterwards ascends a long way upon the side of the brain through the Sylvian fossa. All the branches of the carotid, contained within the skull, are made up of more thin, solid and brittle membranes than the other arteries of the body.

§. 338. But the *vertebral artery*, commonly arising from the subclavian of the same side, though the left has been sometimes seen to spring from the trunk of the aorta, passes on without giving branches through a place of security, 'till it enters a foramen in the transverse process of the sixth vertebræ of the neck, after which it continues with alternate flexures

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to ascend through the oblique processes of the other vertebræ of the neck; from whence, at each interval, it sends off smaller branches to the muscles of the neck, and communicates with the lower thyroideal; other branches again somewhat larger go from it backward, together with each of the nerves, to the pia mater of the spinal medulla; but before, the branches are larger though less numerous, to the same spinal medulla, and communicate by an anastomosis, with its spinal artery anteriorly. Lastly, growing less about the second vertebra, and being inflected with a large curvature round the transverse process of the first vertebra, it there sends off considerable branches to two of the muscles of the neck; also small branches it sends off in its course through the great foramen of the occiput or skull to the dura mater, which lines it, and the adjacent cavities that contain the cerebellum; after which, it goes on through the said foramen into the cavity of the skull. There ascending, according to the course of the medulla oblongata, the right trunk, by degrees, approaches nearer to the left, and is conjoined together with it (in an extraordinary manner, hardly to be found in other parts) into an artery called the *basilaris*, which is suspended in the pia mater all along under the pons Varolei. From the vertebral arteries, before they are conjoined together, pass out branches, which go to the lower surface of the cerebellum, and are deeply inserted under the fourth ventricle to the inner substance of the cerebellum. These are the

branches sent off by the spinal arteries. But there are some instances where they arise conjunctly from a single trunk; and then the next artery, which it sends off, is the basilaris: but besides branches to the medulla oblongata and crura of the brain, it gives first the lower arteries of the cerebellum, then the upper and superficial ones, with small branches, to the fore part of the fourth ventricle. Amongst the foresaid branches also arises an artery, which accompanies the auditory nerve. Finally, the basilaris, at the fore-part of the pons, divides into two branches, each of which communicates with the posterior branch of the carotid, and goes partly to the posterior lobe of the brain, partly to the surface of the cerebellum, and in part to the nates, testes and upper portion of the charoidal plexus; and in part likewise enters the anterior ventricles of the brain, and goes along with the lower portion of the choroides to the corpora striata, fornix, &c.

§. 339. From the foregoing history of the arteries belonging to the brain, it appears, that a very great quantity of blood is in every pulsation sent to this organ, insomuch that it makes above a sixth part of the whole blood, that goes throughout the body, and derived from trunks that are very near the heart, springing from the convexity of the aorta. From hence it is probable, that such parts of the blood go to the head, as are most retentive of motion. Is not this evident from the effects of mercurials exerting themselves almost in the head only; from the sudden force and action
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of inebriating spirits upon the head; from the short stupor which camphor excites; from the heat, redness and sweat, which happen oftner in the face than other parts of the body; to which add the more easy eruption of volatile and contagious pustules in the face? The well-guarded passage of these great and important vessels, in their ascent to the head, defends them from any great injury. The frequent inosculations of one trunk, with the other going to the head, as well as the frequent communications of their branches among themselves, lessen any danger that might ensue from obstruction. The considerable flexures of the vertebral and carotid artery serve to moderate the impulse of the blood coming to the brain, since a great part of the velocity, which it receives from the heart, is thus spent in changing the figure of the inflections. To which add, that some authors do not improperly observe the arteries here grow larger or somewhat wider.

§. 340. The history of the brain deservedly begins from its integuments. Such a tender part so necessary to life, we observe providently surrounded on all sides, first by a sphere of bones, consisting of many distinct portions; by which means it is rendered extensible, at the same time that it is effectually guarded against external pressure. To the internal surface of this bony sphere, on all sides, grows a very strong membrane, composed of two plates sufficiently distinct, which are firmly attached by an infinite number of small vessels, as by so many

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feet

foot-stalks to the whole surface of the said bones, so as to be no where easily separable in a healthy person; these, being very thin and smooth, adhere less firmly to the bones, but more strongly to the sutures, so called from their figure, which join the bones of the skull one to another. In younger subjects, the adhesion of the dura mater to the skull is such, that the separation of it pulls off the fibres of the bones to which it is connected. In adults, many of the vessels, which it inserts, being effaced, renders it more easily separable; yet it is not without some force, even in those, that the dura mater can be separated from the skull. From the rupture of these vessels, which enter the bones of the skull, appear those bloody drops, which are observable after removing the cranium. Hence appears the vanity of all that has been advanced concerning the motion of the dura mater. But for the motion, which is remarked by the writers of observations upon wounds in this part; that, being præternatural, was the consequence of the beating of the arteries, in a part where the resistance of the bone was now removed, while the rest of the dura mater, next to the skull, sustained the force of the heart without motion. [Also that part, which is properly the dura mater, has neither nerves, nor sensation or irritability.]

§. 341. The *outer plate* of the dura mater, which adheres to the bones of the skull, is to them instead of a periosteum, and supplied or furnished with small nerves and blood-vessels coming through all the small holes of the skull;
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from whence, and from its cohesion with the periostia of the head, spine and whole body, it has from the Arabians received the name mater. The *internal plate* of the dura mater is, in most parts, continuous with the former, but, in some subjects, it recedes a little from it, as in the great sphenoidal wings, and at the sides of the sella equina, where a good deal of blood is poured betwixt them; and they likewise recede thus upon the sella equina itself: the same plate, having left the outermost, adhering firmly to the bones of the skull, descends doubled together to form the falx, which arises first from behind the processus cristæ-galli of the multiform bone, afterwards from the crista itself, and from the whole junctures of the bones of the forehead and the parietals; and lastly, it arises from the middle of the back part of the occipital bone, and growing broader backwards, it divides the hemispheres of the brain, betwixt which it is placed; from whence departing, it is extended to the corpus callosum. That there are shining fibres in this part, dispersed towards the longitudinal sinus from the conjunction of the tentorium, in the shape of branches and palm twigs, is certain; but it does not, therefore follow, that they have any muscular motion; and betwixt these fibres frequently there is no membrane, only natural foramina are interposed. The falx is both joined to, and continued from the middle tentorium, which is extended laterally. In the same manner, with some difference of situation, the said falx sends out a short plate down-

ward, which divides the cerebellum, together with the strong tentoria or lateral productions, which, arising from the cruciform protuberance of the occiput, are interposed transversely betwixt the brain and cerebellum, extended as far as the limits of the os petrosum, and connected to the anterior clinoid processes, leaving an oval aperture for the medulla oblongata to descend freely. These productions of the dura mater serve to prevent the parts of the brain from pressing one another, in all situations and postures of the body; and they likewise hinder one part of the brain from bruising the other, by any shock or concussion. Hence it is, that in the more active quadrupedes, where a concussion is more likely to happen, the brain and cerebellum are divided by a bony partition.

§. 342. In the external surface of the pia mater, not far from the sinus of the falx, are placed small glandules, of which some are more hard and red than others, seated in the reticular texture of the hard membrane, looking towards the sinus, to whose cavity they are opposed, in such a manner, that some of them are contiguous to the hollow of the sinus; others are so placed at the insertion of the larger veins into the pia mater, that, together with the former, they make up a continued range or series; others of them again are soft, oval, and disposed in heaps or assemblages. But the vapour, which exhales from the surface of the pia mater, is not separated by these glands, for it is every where exhaled, even into the ventricles, where there are none of those glan-

glandules; and it plentifully transpires every where from the mouths of the least arteries, as we see, by experience, when water or fish-glue are injected, which sweat out through every point in the surface of the dura mater.

§. 343. The next covering of the brain, which is more close to it, exactly resembling its figure, and adapting it to that of the hollow skull, has been, by some, denominated, from its tenuity, *arachnoides*, i. e. like a spider's web. This very thin or tender membrane, being pellucid like water, every way furrounds the brain, whose inequalities it climbs over, and, according to its little strength, ties together with the larger vessels, over which it is spread, in such a manner, that the said vessels seem to run betwixt the pia mater and arachnoides; which last is, therefore, no part or lamella of the pia mater, from which it differs by situation, and that, in a most remarkable manner, more especially on the spinal medulla.

§. 344. The third or innermost covering of the brain, which is soft and cellular, is properly the *pia mater*. This immediately invests or furrounds the whole surface of the brain on all sides, is extremely vascular, tender, and somewhat of a cellular substance. The cells of which again contain an infinite number of most minute vessels, which are, by this cellular fabric, exhibited like little roots or bunches of cotton to the brain. This descends betwixt every furrow and fissure of the brain and cerebellum, and even insinuates itself into the spinal medulla. This, being received into the

cavities of the brain, changes its fabric, so as to become soft and almost of a medullary consistence, more especially when the subject, that comes under the examination of the knife, has lain dead some considerable time, yet then it is able enough to demonstrate the vessels themselves in its fabric.

§. 345. The *veins* of the brain are not disposed in the same manner with those in other parts of the body. For neither have they any valves, nor do they run together in company with the arteries, nor have their trunks the structure which is commonly observed in the other veins. The veins, therefore, which come out of the innermost cavities of the brain, those which are spread upon the striated bodies, the veins of the choroide plexus, with the lucid septum and the anterior ventricles, are collected together into trunks, which, at last, meet in one great vein or often two, which, being accompanied with many small arteries of the choroide plexus, descends backward to the partition of the brain and cerebellum (§. 342.). In that place, it receives veins arising from the posterior and lower part of the brain, and some of the cerebellum, from whence the blood passes into a sinus, which is a kind of vein included in a reduplication of the inner plate or membrane of the brain, into which the veins, to shorten their length, are generally inserted; and this sinuous vein generally descends to the greater sinus on the left side, though sometimes it ends bifurcated, one branch on each side.

§. 346. The upper and superficial veins of the brain are large, and spread in the windings, with which the brain on all sides abounds. With those veins, through the whole surface of the brain, are inserted other veins of the dura mater; and others, which enter by peculiar orifices, into the falciform sinus. From thence the veins, gradually collected together, pass along most of them forward, some few of them in a strait direction, and others backwards, of which those forward are the largest, and open themselves by sinusses obliquely cut off into the long *falciform sinus*, which is formed by the right and left plate of the internal membrane of the dura mater, which meet together below upon the upper part of the back of the falx. From thence it is of a triangular figure, convex in its upper side, beginning with a slender origin at the seat of the foramen cæcum, that is placed above the cristagalli; from whence it ascends and follows in the course of the falx, until that joins the tentorium; it is generally inclined to the right side, and takes the name of the *right transverse sinus*, which then goes by a peculiar channel in the occipital and temporal bone, transversely to its incurvation at the opening of the jugular vein; in which place being much enlarged, it receives the lower sinus petrosus, together with the occipital ones, which are hereby discharged into the jugular vein. But the left transverse sinus resembles the former, and is like that conveyed in a similar course to the jugular vein, into which it is rather inserted on the right side than

continued, as it were, in a trunk. Into the said longitudinal sinus, the fourth sinus (§. 345.) together with the occipital sinus, usually insert themselves. But there are some instances, where all these are disposed, in a different manner, by an insertion of the longitudinal, into the left transverse sinus; and then the right transverse sinus receives the fourth and the occipital one. At other times they are equally divided into two transverse trunks; and sometimes the middle sinus joins the transverse ones.

§. 347. There is a slender and rounder sinus, which runs along the lower and thicker margin of the falx, somewhat of an irregular figure, receiving veins from the falx itself, and communicating likewise with the upper sinus; it also receives veins from the adjacent hemispheres of the brain, and from the corpus callosum. Where the tentorium joins with the fore-part of the falx, this is commonly there inserted, into the fourth sinus.

§. 348. The *lower veins* of the brain, which lie next to the basis of the skull, are variously inserted. The foremost of them coming from the fossa Sylviana, collected together into some trunks, are inserted into the cavernous sinus or triangular interval, that lies at the side of the sella equina, betwixt the external and internal plate of the dura mater. Other veins, from the pons itself, lead into the upper sinus petrosus. Other posterior veins, which come from the posterior lobes of the brain, are inserted in great numbers into the transverse sinus that is seated within the tentorium.

349. The upper veins of the cerebellum, meeting together in large trunks, partly open themselves into the fourth sinus, and in part into the transverse sinus. The lower veins, from the cerebellum and medulla oblongata, insert themselves into the upper sinus petrosus.

§. 350. There are still many small sinusses, besides those before-mentioned. The most anterior of them, which is commonly *like a circle*, is larger behind than in its fore-part, which is slenderer, and surrounds the pituitary glandule betwixt the clinoide processes, communicating with the cavernous and with the lower petrose sinusses; likewise communicating betwixt those processes and the carotid of nerves, artery, and again by the way of the sixth pair, with the upper petrose sinusses behind the fifth nerve. There are some instances, where this sinus receives the ophthalmic vein; and sometimes the transverse, joining to the cavernous sinus, supplies the place of this circular sinus, or else is present with it at the same time.

§. 351. The upper *petrose sinus* is conveyed backwards in a cavity of the os petrosum, and takes its origin from the extremity of the anterior sulcus of the os petrosum, where it communicates with the cavernous sinus, and receives the insertions of the veins of the dura mater, and sometimes of the anterior veins of the brain itself, mentioned before (§. 348.); then it is inserted into the angle of the transverse sinus, where it begins to be bent. Another vein likewise descending down through the os petrosum, is, in like manner, inserted into
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the angle of the transverse sinus. The *lower sinus petrosus*, which is larger, goes round the root of the bone of this name, and communicates with its fellow behind the clinoid process; also twice it communicates with the cavernous sinus and with the upper sinus, and is conjoined under the nerve of the fifth pair, being finally inserted into the jugular fossa or cavity. Moreover, it receives some veins from the vertebræ. To the same outlet also the *occipital sinus* leads on each side, which being pretty large, goes round the margin of the foramen, 'till, arriving at the falx of the cerebellum (§. 341.), it is sooner or later inserted, together with its fellow, for the most part into the fourth sinus, and with that into the left transverse one, or into the longitudinal sinus itself; or lastly, by a divided extremity into each of the transverse sinusses. This sinus receives the lower and posterior veins of the dura mater, and some others from the vertebræ.

§. 352. The anterior occipital sinus is irregular or multiform, partly transverse and partly descending to the great foramen, being variously conjoined with the lower petrosal sinusses; from whence it passes with the nerves of the ninth pair, and either communicates through a peculiar foramen by emissaries into the outer vertebral vein, or other branches passing out below, open into the venal circles of the spinal medulla. But the *cavernous sinusses* of the dura mater (§. 345.), being surrounded with a good deal of cellular substance, receives, besides the fore-mentioned sinus (§. 349, 30.), large

large veins already described, and transmits them with peculiar veins, together with the first and second nerve, and third branch of the fifth pair, with a large artery of the dura mater (§. 335.), and the internal carotid (§. 336.); also it sends out other emissaries through a foramen, which is not constant in the great wing, which form inosculations with veins placed on the outside of the skull leading to the jugulars, and especially with the largest pterygoidal plexus of veins belonging to the nose. The great vein of the dura mater, whose branches are accompanied with an artery, is often double and inserted into one of those emissaries which we have described. In the same manner, the veins of the pericranium pass through small holes in the parietal bones into the longitudinal sinus, as the occipital veins pass through the mastoide hole into the transverse sinus thro' the anterior channel of the occipital bone; and the external vertebral veins are inserted into the jugular sinus; and others of the anterior occipital veins, accompany the nerve of the ninth pair. Thus there are an infinite number of ways open to the blood, by which it may pass from the sinusses, wherein it is often collected in too great a quantity; but, by this mechanism, it may escape either on one side or the other, according to the different laxity and declivity of the parts. [Hence no violent symptoms follow upon tying either or both of the jugulars or other large veins.]

§. 353. The great quantity of blood, which goes to the brain, the greater impulse with which

which it is sent into the carotid arteries (§. 339.), and the immunity of this part from every kind of pressure by a strong bony fence, joined with the slower motion of the blood through the abdominal viscera and lower extremities, also the perpetual exercise of the brain and senses, do all determine a copious flux of blood to these parts, and are likewise the causes, why, upon every increase of the circulation, the head is more particularly and surprisingly filled with blood. Hence it is, that a redness of the face, a turgescence and sparkling of the eyes, with a pain and pulsation or throbbing of the arteries in the head, are so frequently followed with a bleeding at the nose, by violent exercises or motions of the body. From hence, therefore, it is evident, that, if the veins were of a thin and round structure in the brain, they would be unavoidably in greater danger of breaking, whereby apoplexies (to which, in their present state, they are often liable) would be much more frequent. To avoid this, therefore, nature has given a different figure to the veins which carry out the blood from the brain, by which they are more easily and largely dilatable, because they make an unequal resistance; their texture is likewise very firm, and more difficultly broken, especially in the larger sinusses, which perform the office of trunks; for as to the sinusses of the lesser sort, they are either round, half cylindrical, or of an irregular figure. Besides this, nature has guarded the sinusses by cross-beams, internally made of strong membranes, and detached from the right
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to the left side within the sinus, which, in greater distensions, they draw towards a more acute angle, which is capable of a larger dilatation, strengthening and guarding it from a rupture at the same time. She has likewise, in these veins, provided numberless anastomoses, by which they open mutually one into another, and openly communicate with the external vessels of the head and with those of the spinal medulla, by which means they are capable of freeing themselves more easily, whenever they are overcharged with blood, (§. 352.).

§ 354. It is by some queried, whether a part of the arterial blood is not poured into the sinusses of the brain? and whether they have not a pulsation excited from that blood? that they have no pulsation is past doubt, because the dura mater every way adheres firmly to the skull, but much more firmly in those parts, which are the seats of the sinusses. Indeed they receive liquors injected by the arteries; but whether those transude through the small exhaling arterial vessels, or whether they first make a compleat circle through the veins, as is most probable, we are not yet furnished with experiments enough to determine.

§. 355. Thus all the blood of the brain or encephalon is finally conveyed into the jugular veins, which are very dilatable, and, for that reason, guarded with valves to prevent a return of the venal blood from the right auricle, being, at the same time, surrounded with a good deal of cellular substance. For as to the blood, which goes to the head by the vertebral veins, it is a

very inconsiderable quantity; but the ample jugulars answer, in such a manner, to the great upper vena cava, in a direct course, that they afford the high way for the blood to return back to the heart.

§. 356. Whether or no there are lymphatic vessels to be seen in the brain, is by some questioned? Indeed we read descriptions of them in the pia mater, and in the larger choroidal plexus; but, for my own part, I have never been able to see them, and possibly there are none to be seen, since there are no conglobate or lymphatic glands in the brain, which are always near at hand, wherever any of these vessels are to be found. As for the various accounts, which are given of the pituitary glandule, of the infundibulum, and of the ducts, which lead from thence into the veins of the head, absorbing and transmitting a water from the ventricles of the brain; they are not supported by anatomical experiments, which make it more probable, that the vapour, which is secreted into the ventricles of a healthy person, is, in like proportion, absorbed again by the inhaling veins, or if any part abounds, that descends through the bottom of the ventricles to the basis of the skull, and from thence into the loose cavity of the spinal medulla. That this is the case, appears from palsies, which ensue on one side of the body after apoplexies; and from the bifide spines or watry tumours in the lower part of the spinal medulla, following in those who have an hydrocephalus. But the said pituitary glandule receives into itself a
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strong medullary cone, which yet is inserted soft and very much like the cortical substance of the brain, more especially in its posterior appendix, which is extended to the posterior clinoid processes; but it is neither of any certain or known use, nor like unto any glandule, with which we are acquainted.

§. 357. It now remains for us to speak of the encephalon itself. But many are the parts included under this general denomination. By the *brain*, properly so called, we understand that upper and soft viscus, which is contained in the skull, and which is lodged by itself in its fore-part, but backward 'tis incumbent over another considerable part, called the *cerebellum*, which lies in the posterior and lower cavities of the occipital bone, under the membranous tentorium, which parts it from the brain, whose lower, middle and white portion, descending before the cerebellum, is, in part, called the pons, and, in part, the *medulla oblongata*.

§. 358. The *figure* of the brain resembles that of half an egg, which is deeply divided longitudinally, but not cut through above half way. Both the upper and lower surfaces are full of many gyri or convolutions, which pretty deeply cut or divide the brain with round ends or angles into undulated portions. Upon the surface of the said lobules or portions lies the *cortex*, extremely soft and inclined from a yellow or red to a grey or ash colour, being the most tender of all parts in the human body: this inwardly is filled with the *medulla*, which is almost perfectly white, except that, in many places,

places, it is perforated by red arteries, which are more simple and perpendicular, or straight, than in other parts. This medulla is more solid and more capable of sustaining its figure, notwithstanding it is very soft, and abounds in a greater quantity than that of the cortex. The greater posterior branch of the carotid artery (§. 337.) first divides the right and afterwards the left hemisphere of the brain into an anterior lobe, which is the larger, and a posterior lobe, which is the less.

§. 359. The fabric of the cortex has been a long time controverted; but it is now sufficiently evident, from anatomical injections, that much the greater part of it consists of mere vessels, which are every way inserted from the small branches of the pia mater, detached like little roots into the cortical substance, and conveying a juice much thinner than blood in their natural state, although, in some diseases and by strangling, they often receive even the red parts of the blood, more especially in brutes and birds. The remaining part of the cortex, which is not filled by any injection, is either an assemblage of veins, or of yet smaller vessels; for no other dissimilar parts are apparent in the cortex, whilst it is in an entire or natural state; from whence one may conjecture some part of it to be tubular, and the other part solid. As to glandules making the fabric of the brain, that notion has been discarded by universal consent; nor indeed has there been any other opinion received with less probability than this.

§. 360. In order to gain a knowledge of the nature of the medulla, we are to consider the anatomical structure of this part of the human brain, compared with the brains of brute animals and fish. Therefore this part of the brain, which follows immediately under the outer gyri or convolutions of the cortex, is of a white colour, and becomes gradually broader and more abundant; so that, at length, it makes up the whole oval section of the brain, except only the gyri in the surface, which make the cortex. In this part, the two hemispheres of the brain, as before observed, are divided but half way through, which hemispheres (§. 358.) here continue their cohesion with the medulla in the middle. That part of the medulla, which is extended under the falciform process, but at some distance from it, is called *corpus callosum*, in the surface of which run two parallel white stripes. But the anterior extremity of this callous body is lost in the substance of the crura, coming from the anterior lobes of the brain, as likewise are the posterior crura with the foot-stalks of the hippocampus; moreover, the whole surface of this callous body is streaked with transverse fibres, which are continued, but extenuated into the next adjacent medulla of the brain itself.

§. 361. As to the remaining parts of the brain, a scrutiny is more difficult to be made into them; for the brain is not a solid body, but begins to be hollow internally from the lower part of its medulla, which is incumbent

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upon the multiform bone, at which place the greater crus of the brain passes out from it; and in this cavity, the medulla is only covered with the pia mater, which ascends backward, and then turning continues its course forward and upward. Next, the brain divides itself near the posterior extremity of its callous body, and, at the same time, sends one of its shorter posterior portions into the posterior lobe of the brain, turning its extremity inward. But the anterior portion is continued a long way by the side of the callous body, parallel to the horizon, and turning its horn and end outward, it is terminated in the anterior lobe of the brain. This cavity, of which there is one in each hemisphere of the brain, is called its triangular or anterior *ventricle*; and it is naturally filled with a vapour, which being frequently condensed, puts on the appearance of water.

§ 362. This cavity is full without any intermediate space by the close meeting together of the sides of the upper and lower medulla. The lower side or pavement of this part is variously figured. In its fore-part, it forms a horn, below which there is a hill moderately convex, and of considerable length, covered with a membrane that is extremely vascular, and being outwardly of an ash or grey colour, is called the *corpora striata*; because inwardly they exhibit to the view white streaks, intermixed with a good deal of the cortex. More inwardly and backward there are two other similar hills of the medulla obscurely striated, but mixed, however, with some portion of the

the cortex, and so incumbent together, that, in their upper part, they frequently cohere; and these continuing their course through the horn of each anterior ventricle, descend to the basis of the skull, and there generate the optic nerves, of which these are called the *thalami*. Betwixt the said striated bodies and those *thalami*, lies an intermediate white and streaked medullary portion, called the double semicircular center; and this, being extended into a medullary fascia, is continued across from the right into the left side. But then the corpora striata chiefly join and compose the *crura* or foot-stalks of the brain.

§ 363. It is to be observed, that the corpus callosum medium projects or rises up in the common axis or middle of those ventricles. Behind, this body lies contiguous and incumbent on the fornix or arch; but before, there are two similar medullary partitions, which descend from this body the whole length of the corpora striata; and this part, which, in its middle, includes an anonymous cavity, goes under the name of *septum pellucidum*. This septum is continued to the *fornix*; that is to say, the four-horned medullary tracts, which took their anterior origin from peculiar mammillary protuberances in the *crura* of the brain, at the basis of the skull behind the optic nerve, now concur, and by a meeting together of the anterior part of the brain in that place (§. 362.), do there unite into one trunk. This is incumbent upon an interval of the striated bodies, and upon another interval of the *thalami*;

from whence it degenerates partly into a broad thin fimbria, and partly into another tubercle, which is continuous with the fornix and callous body of an half cylindrical figure, and furnished with an opposite *fimbria*. These descend into the lower anterior horns of the ventricles, and at last terminate by a sort of convex fulcated end, imprinted by the cortex and named *p. des b. pp. can. pi.*, which are outwardly medullary, inwardly of a cortical substance. A like protuberance is continued in the posterior horn of the ventricle. Betwixt the departing crura of the fornix, the transverse medullary portion, which is behind the middle plexus of the ventricles, and painted with streaks, or palmated, is called the *psalterium* or harp.

§. 364. Within the anterior or lower part of each of the ventricles, begins the vascular *plexus*, called *choroides*, included in the pia mater only, except which, it lies naked in the cavity of the skull, made up of a great many small arteries (§. 337, 338.), together with little veins leading to the larger trunk (§. 346.); all which numerous vessels, joined together by the pia mater, resemble a curtain variously folded. With these are intermixed many small pellucid glandules of a round figure, resembling hydatids. When those plexusses have reached the anterior extremity of the thalami, being afterwards reflected and united together, they gradually descend through the crevice of the third ventricle as far as the pineal glandule, where they terminate by the meeting of other vessels

vessels (§. 338.), and then continue to insinuate themselves within a large portion of the pia mater, to the lower part of the brain. From this plexus, doubtless, proceeds the internal warmth of the brain, with its exhalation and inhalation. [But the choroidal plexusses become very broad, where the anterior ventricles of the brain begin to descend, and thence, contracting gradually downward they project their extremities to the ends of the anterior ventricles, covered only with the pia mater.]

§. 365. Betwixt the thalami, applied one to the other almost with a plain surface, there is a natural fissure terminating the crura of the brain, which meet together in the basis of the skull, and this is called the *third ventricle*, which leads by a declivity, like a funnel, forward into the column of the medulla; which, though hollow in brutes, is yet evidently less tubular in man, and connected to the pituitary glandule (§. 356.). Backward, the thalami are conjoined together in the bottom of the ventricle by a medullary fascia; but the ventricle itself, being inclined forward before the nates and testes, leads to the fourth ventricle. In this course, is extended round it a broad, short, medullary fascia, stretched out from the bottom of the right thalamus to the bottom of the left. But there are other fibres, which go inclined towards the right through the length of the thalami, and which likewise join the thalami together on each side behind the former transverse fasciculus, and before the pineal glandule. Those are generally ascribed to the

pineal glandule itself, with which they cohere either not at all, or by very short productions.

§. 366. Again behind the thalami, those transverse figured eminencies of the medulla meet together, which conjoin the medulla of the right and left posterior lobes of the brain. In this part backward are engraved or cut out four oval eminences, which are outwardly smaller, called the *naces* and *talles*, and which are of a substance inwardly cortical, but outwardly medullary. Upon these is seated a cortical glandule, somewhat oval and conical, spread with many small vessels, into which the choroide plexus here degenerates; and this has been celebrated by the name of *pineal glandule*. [Betwixt these four protuberances and the crura of the oblong medulla, passes a groove or channel in the same direction from the third to the fourth ventricle, manifestly open, and called the aquaduct]

§. 367. The whole medulla of the brain is, in its lower part or basis, collected together into two very thick compressed columns, distinguished in their surface by a line running according to their length; and these have internally a cortical substance. These, which are the *crura of the brain*, meeting together downward, are covered by the subjacent crura of the cerebellum, and are inserted by apparent strata of fibres into the pyramidal bodies of the medulla oblongata; and with the other deeper fibres, which separate the inner transverse fibres that come from the cerebellum from the preceding, meet together with the medulla cerebelli to
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make up the beginning of the medulla oblongata.

§. 368. The *cerebellum*, as it is less, so it is more simple than the brain. It has two lobes, but no where deeply parted, united above and below in their center to a ring of the same fabric with itself, called the *processus vermiciformis*. This part of the encephalon contains a great deal of the cortex, with a less proportion of medullary substance. And here likewise the cortex is placed in the circumference, but marked with gyri or convolutions, which are rather parallel to each other, so as to form circles; by which the small lobules or portions are distinguished, but not deeply, and afterwards send out each of them their medulla, which is, by degrees, so collected together in rays or branches, meeting in one trunk, that the whole resembles the figure of a tree. This medulla, collected together into the large crura of the cerebellum, terminates or goes off three ways; one part ascends towards the nates, where it joins with the medulla of the brain; but the right and left parts of the medulla are conjoined to each other by transverse striæ behind the nates. Another portion descends into the spinal medulla, and terminates in peculiar protuberances, which are both anonymous, and have other cortical portions near them. A third portion, which is larger, and variegated internally with ferrated lines of the cortical substance, goes transversely downward under the crura of the brain, which it embraces, and by twice intermixing alternately with their transverse medul-

lary fibres (§ 367.), it is in a great measure confounded together with them.

§. 369. In this manner the *pons* is first formed almost of an oval figure, depressed in its middle, having transverse fibres on all sides; namely, from a conjunction of the crura of the brain descending above those of the cerebellum, and passing out from the medulla of the brain transversely near the cerebellum. Afterwards the *medulla oblongata*, continuous to the pons, being partitioned in its middle by a peculiar sulcus, is internally variegated and streaked with a substance like the cortex, and descends of a conical shape, inclined to the great foramen in the occiput. This medulla has two pair of tubercles before the pons; the outermost, from their figure, called *corpora olivaria*; and the innermost, *pyramidalia*; because they lessen downward like a cone, and these are immediately divided by a sulcus, thro' which the pia mater enters. But betwixt the medullary worm-like process of the cerebellum, is formed a cavity above the tubercles (§. 68.), where it grows broader of a rhomboidal figure, and is called the *fourth ventricle*, shut in its back part by the valvula magna, or a medullary process from the cerebellum, uniting the velum to the nates (§. 36.); being cut into the medulla oblongata, and answering to the canal that is covered by the nates and testes, called the aqueduct. In this last ventricle, as well as in the foregoing, is lodged the plexus choroides, only less in bulk, together with an upper sulcus, called calamus scriptorius. Each of these
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fulci or divisions are continued down along the medulla spinalis, both in its anterior and posterior side; and therein transverse fibres are detached in its upper part from the right to the left side, both of the medulla oblongata and spinalis. [But two or three of the transverse streaks, that arise from eminences, which intercept a sulcus, are inserted into the soft part of the acoustic nerve; and others of the same kind ascend to the crura of the cerebellum.]

§. 370. All the medulla of the brain and cerebellum goes out from the skull, through particular openings towards certain parts to which it is destined. The smaller bundles of this medulla, we call *nerves*; but the larger, descending through the spine, we call the *medulla spinalis*, which is a continuation of that called oblongata (§. 369). But the nerves, which are bundles of the medulla, and very soft in their origin, are composed of straight parallel fibres in distinct threads. These nervous cords, after they have gone forward some length, covered with the firm pia mater of a redish colour, are afterwards united into a more tough or permanent string; and then going off from the brain, they hasten to their proper opening in the dura mater, and thence run down through the intervals of the channels formed by that membrane, 'till they meet with an opening in the skull, out of which they pass through the membranous funnels of the dura mater. The nerve, having arrived without the skull, is commonly surrounded by the dura mater, so as to become very solid and firm. Thus it is in the
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lary fibres (§ 367.), it is in a great measure confounded together with them.

§. 369. In this manner the *pons* is first formed almost of an oval figure, depressed in its middle, having transverse fibres on all sides; namely, from a conjunction of the crura of the brain descending above those of the cerebellum, and passing out from the medulla of the brain transversely near the cerebellum. Afterwards the *medulla oblongata*, continuous to the pons, being partitioned in its middle by a peculiar sulcus, is internally variegated and streaked with a substance like the cortex, and descends of a conical shape, inclined to the great foramen in the occiput. This medulla has two pair of tubercles before the pons; the outermost, from their figure, called *corpora olivaria*; and the innermost, *pyramidalia*; because they lessen downward like a cone, and these are immediately divided by a sulcus, thro' which the pia mater enters. But betwixt the medullary worm-like process of the cerebellum, is formed a cavity above the tubercles (§. 68.), where it grows broader of a rhomboidal figure, and is called the *fourth ventricle*, shut in its back part by the *valvula magna*, or a medullary process from the cerebellum, uniting the velum to the nates (§. 36.); being cut into the medulla oblongata, and answering to the canal that is covered by the nates and testes, called the aqueduct. In this last ventricle, as well as in the foregoing, is lodged the plexus choroides, only less in bulk, together with an upper sulcus, called *calamus scriptorius*. Each of these
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fulci or divisions are continued down along the medulla spinalis, both in its anterior and posterior side; and therein transverse fibres are detached in its upper part from the right to the left side, both of the medulla oblongata and spinalis. [But two or three of the transverse streaks, that arise from eminences, which intercept a sulcus, are inserted into the soft part of the acoustic nerve; and others of the same kind ascend to the crura of the cerebellum.]

§. 370. All the medulla of the brain and cerebellum goes out from the skull, through particular openings towards certain parts to which it is destined. The smaller bundles of this medulla, we call *nerves*; but the larger, descending through the spine, we call the *medulla spinalis*, which is a continuation of that called oblongata (§. 369). But the nerves, which are bundles of the medulla, and very soft in their origin, are composed of straight parallel fibres in distinct threads. These nervous cords, after they have gone forward some length, covered with the firm pia mater of a redish colour, are afterwards united into a more tough or permanent string; and then going off from the brain, they hasten to their proper opening in the dura mater, and thence run down through the intervals of the channels formed by that membrane, 'till they meet with an opening in the skull, out of which they pass through the membranous funnels of the dura mater. The nerve, having arrived without the skull, is commonly surrounded by the dura mater, so as to become very solid and firm. Thus it is in the

optic nerve, in the fifth pair, and in others ; but in some again there does not appear to be any dura mater surrounding the nerve, as in the olfactory nerves, in the soft portion of the auditory nerve, and the intercostal. The nerves now descend naked or less fenced betwixt the muscles, detaching their cords or threads of which they are composed, and are still made up of the medulla covered by the pia mater. Many small threads of this kind are joined together into larger, by the union of the cellular substance that surrounds them, through which run many small arteries and veins intermixed ; and sometimes fat itself is therein lodged. But, in general, the outer covering, common to the whole nervous bundle, is either derived from the dura mater, or, at least, is a hard plate of the cellular substance, wherein all the smaller threads are contained and united into one nerve.

§. 371. It is a principle, in common, to all the nerves of the head, to arise and pass out from the lower part of the medulla of the brain or cerebellum. The olfactory nerve arises with lateral fibres from the interval betwixt the anterior lobe of the brain, but with direct fibres from the medulla of the anterior lobe itself. A great part of the optic nerve springs from the thalami (§. 362.), but some part likewise from the medulla of the brain itself in the basis of the skull near the mammillary protuberance. The third pair of nerves come from the medullary crura of the brain, behind the mammillary bodies or protuberances. The fourth
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from the medullary striæ, which join the foot-stalk of the cerebellum to the nates (§. 368.). The fifth arise plainly from the peduncles of the cerebellum itself. The sixth out of a sulcus (§. 368.), deep from the bottom of the pons betwixt that and the medulla oblongata. The seventh arises with one part softer from the medulla oblongata, and by two transverse striæ, from the fourth ventricle itself; and with another part harder from that portion of the crus of the cerebellum, which lies next the pons. The eighth nerve arises from the interval betwixt the olivary and pyramidal bodies or protuberances, and according to the observation of other eminent anatomists from the fourth ventricle likewise. The ninth arises from the corpora olivaria only. The tenth, by reason of its double root, is reckoned a nerve of the neck, going out with an arch, in company with the upper and lower adjacent nerve. There is, therefore, no nervous branch that arises properly from the cerebellum, unless it be the fifth; for the anterior nerves, the olfactory, optics, and third nerve come from the brain only; and all the rest from those parts, where the medulla, both of the brain and cerebellum, are conjoined together.

§ 372. The *spinal medulla* is a kind of medullary rope or appendix to the encephalon, continued down from the medulla oblongata, as low as the second vertebra of the loins, where it terminates of a rounding conical figure. In the neck its anterior and posterior sides are flat, laterally convex, but in the back it is four square.

square. The pia mater is a proper integument to this part as well as to the brain, since it enters the spinal medulla deeply by each of the fissures (§. 368), and divides it almost into two. The cortical substance, which lies within it, is more obscure than that of the brain. The larger anterior arteries pass back to it from the vertebrals out of the skull, and descend down through the whole length of the pia mater, frequently double and parallel to each other, perpetually making alternate sinous flexures, which form anastomoses with the vertebral arteries about each pair of nerves, likewise with the intercostal arteries and with the branches of those belonging to the loins and sacrum, 'till, at last, the anterior artery, covered with a peculiar coat from the dura mater, goes out and disappears at the coccyx. In like manner, the posterior arteries, which are less, arise and are distributed from the lower arteries of the cerebellum. The spinal veins descend, together with the arteries, from the brain itself, sending out branches, in like manner, on each side, which accompany the nerves like so many circular sinusses, fixed in the dura mater, and corresponding to the number of the vertebræ, all which so communicate one with another, that each has, on all sides, a direct consent both with the uppermost and lowermost; and after having sent out branches, that join the vertebral, intercostal, and lumbal veins, they unite with those of the sacrum. The uppermost of these sinusses anastomoses with the anterior occipital sinusses, (§. 352.)

§. 373. But there is another covering, not spread with any vessels, which surrounds the spinal medulla loosely and at a distance, and is pretty firm, of a watry clearness, called *arachnoides*, and which being longer than the pia mater, is extended to the bottom of the os sacrum, where the nerves, only descending from the medulla, are collected by it into a fasciculus. But in what manner it goes out, together with the nerves, has not been hitherto described.

§. 374. Lastly, the *dura mater*, belonging to the spinal medulla, and continued from that of the cerebellum, surrounds the preceding arachnoides, like which it descends to the bottom of the os sacrum, being larger at its beginning, at the bottom of the neck, and at the loins; but slenderer in the back, and, being connected ultimately by many filaments to the os sacrum, it, at last, disappears in a slender cone. As the nerves pass out through this membrane, it gives them an external covering, and directly thickens or swells with them into a *ganglion*, or hard, oval, redish-coloured knot, in which the rectilineal course of the nervous fibres is interrupted. To this hard covering of the dura mater internally adheres a ligament denticulated at the interval of each of the nerves, which arises from the skull near the course or passage of the ninth pair of nerves, tying the arachnoides to the dura mater by triangular productions in each of the intervals of the nerves, and betwixt the anterior and posterior bundles of the spinal nerves down to the

the bottom. Externally, there is a sort of fat surrounds the dura mater, and also lines internally the covering of the vertebræ of the spine, which, by this means, is so adapted like a tube to the medulla spinalis, that the latter is not liable to be compressed, by the bending of it in any position.

§. 375. The fibres of the spinal medulla, in dropfical subjects and in brute animals, appear very distinct. These medullary fibres go out from the whole anterior and posterior sides of this long appendix, after which the anterior cords are commonly wrapt up in the pia mater, in which they converge together like rays into a larger fasciculus, to which also join similar threads in another bundle from the posterior fasciculi joining together into one nerve, which passing out through the holes of the dura mater betwixt each of the vertebræ, compose the spinal nerves to the number of thirty, answering to the vertebræ. Among these, the spinal nerves of the neck are short and strong, especially the lowermost; those of the back are small, and those of the loins again, with the first pair of the sacrum, are large. But the nerves of the sacrum are smaller. Of these nerves, the longest are those which go out thro' the loins and os sacrum, arising within the back itself. Those covered with their pia mater, accompanied with corresponding arteries, and included within the arachnoide capsule, form a rope of nerves, which is commonly called *cauda equina*.

§. 376. Those nerves are afterwards distributed to all parts of the body in a manner very complex, and not here to be described. But we must not omit to observe, that all the spinal nerves, except one or two in the neck, have both an anterior and posterior trunk, which pass out together betwixt the vertebræ; and that the latter or posterior being distributed to the muscles, only the former send out nervous foot-stalks, which joining the other anterior and adjacent spinal nerves, and having given a small circle that goes to the sixth nerve of the brain, they form together one great source of the principal nerves belonging to the human body, which, communicating with almost all the other nerves of the whole system, send out nervous branches to the heart and all the viscera of the abdomen. This intercostal or spinal nerve forms as many ganglions as are equal to the number of its medullary roots, except where several of those roots meet together into one ganglion; and thus it forms various knots or communications with the crural, brachial, and diaphragmatical nerves, also with the par-vagum and ninth pair of nerves. The other primary or capital nerve is the eighth or *vague nerve*, arising from the brain and joining itself to the intercostal in the bottom of the neck, in the thorax, and in the abdomen; this passes out of the skull in three cords, of which the larger sends branches to the larynx, gula, lungs, and the cordiac plexus itself (§. 94.) to the œsophagus, stomach, and liver. The third of these is the *phrenic nerve*, arising from most
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of the lower nerves of the neck and arms, and sometimes, being increased from the root of the spinal nerve, it descends by the side of the pericardium, and inserts itself into the upper face of the diaphragm; but below it receives nerves from the great plexus of the intercostal nerve. Moreover, the *accessory nerve*, arising by many small roots from the seven uppermost posterior nerves at the neck, and from the medulla oblongata, joins the nerve of the eighth pair going back again into the skull, and seems, by this means, to make a consent betwixt that important nerve and the spinal medulla. Lastly, the nerves of the limbs have at their origin plexusses or knots, and are, on account of their length, harder or firmer in their substance, and much larger than the great nerves which go to the viscera; those of the arms, arise from the four lower nerves of the neck and first of the back; but those of the lower extremity from the nerves of the loins and os sacrum.

§. 377. The nerves divide into branches like the blood-vessels, but in acute angles, and often in a course, manifestly retrograde, growing gradually softer and less in bulk, till, at length, their ultimate extremities, which are seldom visible, seem to terminate in a pulp, by depositing the firm integuments with which they were covered, after the manner which we observe in the optic nerve. But the rectilinear course of the fibres, continued from the brain itself, is such, that it is never broke off by the division or splitting of a nerve into smaller threads;

threads, which only recede from each other by an opening of the cellular substance that tied them together. This appears from the disorders, which are determined not to all, but only to some single parts by injuries of the brain, as a loss of the voice, deafness, dumbness and palsies of particular muscles. They are connected in their course by the cellular substance to the adjacent parts, but have hardly any elasticity; whence they do not fly back after being divided, but only expel, by the contraction of their integuments, the soft medulla, which they include. A great many nerves are sent into the muscles, many of them go to the skin, but fewer to the viscera, and fewest of all to the lungs. They make frequent inosculations with each other like the blood-vessels, and it is principally in these meetings of their branches, arising from different trunks that the nervous ganglia are formed; namely, hard nervous tumours, for the most part replenished with blood-vessels, and included in a firm membrane, but of a use and structure as yet not certainly known. The nerves of the senses only are excepted from these ganglia or knots, together with the eighth pair; but they seem in a manner essential to the phrenic nerves, to the fifth pair, to those of the limbs, to the spinal and to the intercostal nerves, which last are truly spinal nerves.

§. 378. Thus far we are taught by anatomy concerning the brain and nerves; it remains from hence, that we explain the physiological uses of these parts. Every nerve, therefore,

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that is irritated by any cause, produces a sharp sense of pain, and if the cause be great, those muscles, to which the primary or communicating nerve goes, become immediately agitated with a convulsive motion, which is stronger than their natural motion, and not governed or restrained by any power of the will. The same thing is likewise true after death, if the experiment be made soon after, as we see in the heart and other muscles of brutes. (2). Any nerve being cut through, the muscles, to which it is distributed, become paralytic and generally waste away or wither in a slow manner. But if the nerve so cut performed any particular sense, in that case, whether it be cut through or only compressed, the sense is lost; but by removing the compressure from the nerve, if the structure of it was not spoiled by the ligature, the muscles regain their strength. All those effects follow in such a manner, that the parts, most remote from the brain, constantly suffer from the injury of the nerve, without any effect upon those parts that are nearer to the brain. Experiments of this kind have been made upon the recurrent nerve, upon the eighth pair, and the phrenic nerve, with those of the limbs; and lastly, upon the lower dental nerve of the fifth pair.

§. 379. But the medulla of the brain, being vellicated or variously irritated, dreadful convulsions ensue throughout the whole, and this without any exception, whatever be the part of the brain so affected. The same consequences also follow, if the spinal medulla be
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irritated. But if the encephalon itself be compressed in any place whatever, there follows thence a loss of sense and motion in some part of the body, which must be the part whose nerves are detached from the affected or compressed quarter of the brain. This is clearly evidenced from experiments, which have been made on particular parts of the brain disordered; as from those, for instance, in which the origin of the nerves are compressed, as in the optic nerves the sight is extinguished; as the hearing is, from a like affection of the auditory nerve, or as the motion of one arm or leg, or one side of the pharynx is abolished by a compressure upon the roots of their nerves. But in the injuries of the spinal medulla, it is still more evident, that those parts, which receive their nerves arising from the place injured in the medulla, are either convulsed if that be irritated, or rendered paralytic if it be compressed. But when any more considerable or large portion of the brain suffers a compressure, either from blood, water, schirrus, an impacted bone or other mechanical causes, there follows perpetually either a disturbance of all the faculties of the mind, or else a delirium, vertigo, madness, stupidity, or an incurable sleepiness; all which disorders cease upon removing the compressing cause. Lastly, if the cerebellum, or the corpus callosum, and more especially the oblongated or spinal medulla, entering the neck, be injured in like manner, death immediately follows; because,

from those parts, principally arise almost all the nerves of the heart, (§. 94.).

§. 380. These things being considered, there seems to be no doubt, but the cause of all motion in the human body arises from the brain with its annexed cerebellum and spinal marrow; and that it thence proceeds through the nerves to all the muscles and moveable solids of the body. The cause, therefore, of this motion cannot reside or dwell in the parts themselves, because otherwise the moving cause would continue to act, after being separated from the brain; nor would it be increased by irritating the brain, or weakened by a compressure of it.

§. 381. Nor is it less evident, that *all sense* arises from an impression of the sensible object upon some nerve of the body, through which nerve, the impression being conveyed to the brain, when it is finally there arrived, represents some idea to the mind. It is, therefore, a false position, that the mind perceives immediately in the nervous branches or sensible organs themselves; for this opinion is confuted by the pains, which a person will feel in a limb after it has been cut off, and from the interruption or removal of all pain by a compressure of the conveying nerve, with disorders of the senses from affections of the brain.

§. 382. Whether or no this faculty of perceiving impressed objects by the mind, and of ushering out the motions, which follow either of necessity or from the will, be privileged in common to the whole brain, cerebellum, and
spinal

spinal medulla; because in those parts are formed the roots which are continuous with the nerves, remains a question? but we are not to believe this from the many instances of wounds in several parts of the brain, from which the senses have received no injury, neither from abscesses, which have largely wasted the lateral hemispheres of the brain, &c. From hence many questions may arise; as whether there be any principal or particular seat of the brain from whence all motion springs, and in which all sensation ends, so as to be the habitation or residence of the mind itself? and whether this part be not the corpus callosum, because wounds therein and the effects of diseases are here more certainly and suddenly fatal? whether the said corpus callosum has a sufficient communication or connection with the whole nervous system for such a purpose? whether there are truly any instances of the fifth, seventh, or other nerves, arising manifestly from this part? whether or no wounds of the spinal medulla are not equally or more fatal; when at the same time we know it is not the seat of the mind; because, being compressed or destroyed, a person will survive a long time with all his mental faculties entire? [Add, moreover, in opposition to this, that, in birds who have no corpus callosum, wounds of the spinal medulla are equally fatal with those in any other part of the encephalon.]

§. 353. Whether or no the seat of the mind is in all those parts, which make the beginning of each nerve, in such a manner, that

the first originations of all the nerves conjunctly make together the true common sensory, where all the sensations are represented to the mind and all motions arise, whether necessary or voluntary? we must confess, that this is highly probable. For the origin of motion does not seem capable of springing from any part below the source of the nerve; and it would be begging the question, to suppose any part of the nerve, which is like the rest in its fabric, to be either void of sense or motion. Nor can the origin of motion (§. 380.) be placed higher than this; for so it will fall within the arteries, which have neither the faculty of sensation nor of voluntary motion; it, therefore, follows, that the seat of the mind, if it be material, must be where the nerve first begins its formation or origin.

§. 384. We come now to explain the manner in which the nerves become the organs of sense or motion; which, as it lies hid in the ultimate elementary fabric of the medullary fibres, seems to be placed above the reach both of sense and reason; but we shall, notwithstanding, endeavour to make this as plain as experiments will enable us. And first, it is demonstrated, that the nerves arise from the medulla of the brain, the truth of which is manifest to the eye in all the nerves of the brain, more especially in the olfactory, optic, fourth and seventh pair of nerves, which continue their medullary fabric a long way before they put on the covering of the pia mater.

§. 385. We must, therefore, next enquire into this medulla, what it is. That the composition of it is fibrous or made up of parallel threads, disposed longitudinally by the sides of each other, appear from innumerable arguments, more especially to the eye in the corpus callosum, in the striatum, and thalami of the optic nerves; but still more evidently in the brains of fish. That the fibres of the brain are continuous with those of the nerves, so as to form one extended and open continuation, appears, by observation, very evidently in the seventh, fourth and fifth pair of nerves.

§. 386. But here a controversy begins concerning the nature of this fibril, which, with others of the like kind, composes the substance of the medulla and of the nerves. That this is a mere solid thread and only watered by a vapour exhaling into the cellular fabric, which surrounds the nervous fibres, has been asserted by many of the moderns.

§. 387. But we are not allowed to receive this opinion for the following important reasons, which we here alledge. The cortex of the brain is, on all sides, vascular, and coheres so manifestly, by an undivided and inextricable continuation with the medulla itself, that no one can either doubt or object against this truth. Moreover, the most considerable portion of the blood (§. 339.) is sent up to this cortical part of the brain, to which the medulla is always proportionable, both in its growth and dimensions. This being duely considered, I conclude, that the small vessels of

the cortex, of which it is composed (§. 359.), are continuous with the fibres of the medulla, of which that part of the brain is wholly made up; and that, therefore, they cannot be solid impervious fibres, because such a fabric will occasion the great quantity of juices, sent to the cortex by the carotid and vertebral arteries, to return back useless, repelled from the solid medulla; again, from analogy, it follows, that the cortex, increasing by growth proportionably with the medulla itself, it plainly appears, that they must have both one and the same common incrementive cause; which cause (by §. 249.) is the greater force of the heart, by which the blood-vessels are elongated. It follows, therefore, that the medulla also must be composed of vessels, which, in like manner, are distended by the same force of the heart.

§. 388. Nor is such a solidity of the nervous fibres reconcileable with the appearances, which follow after wounds in the nerves. For if a nerve irritated required to be struck, and to tremble like elastic cords, it ought to consist of hard threads, stretched out and held fast by their extremities to certain firm or solid bodies, with a considerable degree of tension; for cords, which are either unstretched, soft, or not fixed or fastened at their extremities, afford no sound. But all the nerves are, in their origin, extremely soft, medullary, and very far from all tension; and some of them continue thus soft throughout the whole extent, so far as that goes, of which we have an example in the olfactory nerves, and in the soft portion of the

the auditory nerve, from which we ought more particularly to expect those tremors, which resemble sound. Moreover, when the nerves are hard, they always grow soft afterwards in the viscera, muscles and organs of sense, before they operate; and, therefore, the nervous fibres, being in no state of tension, either in their beginning or ending, cannot be subject to elastic tremors. Even in those most chosen and likely circumstances, the nerves can have no tremors, where they are fastened in a more tense manner to the heart, pericardium and great arteries; because they are closely tied to the adjacent solid parts in their progress by the surrounding cellular substance. Finally, that the nerves are very far from all elasticity, is demonstrated by experiments, in which the nerves cut in two neither shorten nor draw back their divided ends to the solid parts, but are rather more elongated by their laxity, and expel their contained medulla in form of a protuberance. [Again the extreme softness of the medulla in the brain, with all the phenomena of pain and convulsion, leave no room to suspect any sort of tension, concerned in the effects or operations produced by the nerves.]

§. 389. Add to this, that the force of an irritated nerve is never propagated upward, so as to convulse the muscles that are seated above the place of irritation, although the trunk of the nervous cord may happen to be firmer and tighter in that part; which is a consequence altogether disagreeing with elasticity, whose tremors propagate themselves in
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cords and other bodies every way from the point of percussión. These arguments, therefore, serve to demonstrate, that there is a liquor sent through the brain, which, descending from thence through the nerves, flows out to all the extreme parts of the body; the motion of which liquor, quickened by irritation, operates only according to the direction, in which it flows through the nerve, so that convulsions cannot thereby ascend upwards, because of the resistance made by the fresh afflux of the fluid from the brain. Nor is the experiment made upon the phrenic nerve without its force in this argument, by which it appears, that compressing the nerve with a motion downward, the contraction of the diaphragm is increased, but, by compressing the nerve upward, the motion ceases; from whence it is evident, that in the first case the natural course of the nervous liquid is quickened, and in the latter suspended; nor can the nerves ever act as cords, when they never tremble by any pressure, in whatever direction they may be urged by the finger.

§. 390. I believe it is, therefore, certain, that the nervous fibres are hollow, and perform their offices not by their elasticity, but by the motion of their juice. Nor is the objection, which arises from the smallness of these tubes, not visible by any microscope of any force against the proposed arguments; to which add the absence of a swelling in a tied nerve, which, in reality, is not sufficiently true; with other arguments of the like kind, which, indeed,

deed, show the weakness of our senses, but have not any validity against the real existence of a juice or spirit in the nerves.

§. 391. But concerning the nature of this nervous liquid, there are many doubts; for many of the moderns will have it to be extremely elastic of an ætherial or of an electrical matter; but the more reasonable part make it to be incompressible and watry, but of a lymphatic or albuminous nature. Indeed, it is not to be denied, but we have many arguments against admitting any system that has been hitherto advanced. An electrical matter is, indeed, very powerful, and fit for motion; but then it is not confinable within the nerves, since it penetrates throughout the whole animal, to which it is communicated, exerting its force upon the flesh and fat, as well as upon the nerves. But in a living animal the nerves only, or such parts as have nerves running through them, are affected by irritation; and, therefore, this liquid must be of a nature that will make it to flow through, and be contained within the small pipes of the nerves.

§. 392. A watry and albuminous nature is common to most of the juices in the human body, and may be, therefore, readily granted to the juice of the nerves; like the firm serous water, which exhales into the ventricles of the brain from the same vessels, also from the example of a gelatinous or lymphatic juice, which flows out in cutting through the brain in fish, and the larger nerves of brute animals, to which add the tumour, which arises in tied nerves.

nerves. But are these properties sufficient to explain the wonderful force of convulsed nerves, observable in the dissections of living animals, and even in the lesser insects, with the great strength of mad and hysterical people? whether or no is not this difficulty somewhat lessened from the hydrostatical experiments of attraction in small tubes? which, although it may explain the strength and motion, is nevertheless inconsistent with the celerity.

§. 393. Therefore, upon the whole, it seems to be certain, that, from the vessels of the cortex, a liquor is separated into the hollow pipes of the medulla, which are continued with the small tubes of the nerves, even to their soft, pulpy extremities, so as to be the cause both of sense and motion; but the precise nature of this juice does not seem to be yet known. That it is extremely moveable, sufficiently appears as well from the nature of the blood that goes to the brain (§. 339.) as from the effects or appearances which follow from it, and from the nature of tenuity itself, by which Sir Isaac Newton has observed the powers of bodies are increased. But we must well distinguish this juice from that visible thick liquor, which distils from the small vessels, which run in the cellular fabric betwixt the threads of the nerves.

§. 394. If it be asked, what becomes of this nervous juice, which cannot but be separated and distributed in great abundance from so large a quantity of blood, passing the brain very swiftly, in comparison of the slower moving

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ing blood, from whence the milk is separated in the breast, and the urine in the lesser renal artery, or by a comparison with the mesenteric artery? it may be answered, it exhales probably through the cutaneous nerves; and some have judged, that it also exhales into the various cavities of the body, as that of the stomach, intestines, &c. but that it exhales into the blood-vessels, does not seem very consistent with the course of nature; although it may be supposed to be taken up by the least absorbing veins, which by degrees open into the larger. That thus it may be resorbed from the cavities of the body, is not inconsistent. But whether it can return again within the same nerves to the brain, so that the nerves can resemble arteries and veins as to the course of their spirits? or whether sensation arises from such a return, are as yet mere conjectures?

§. 395. But then, what is the design of so many protuberances in the brain, what are the particular uses of the ventricles, nates, and testes, with the distinction of the brain from the cerebellum, and the communication betwixt one side of the brain, cerebellum and spinal medulla, with their opposite sides by so many transverse bundles of fibres. These still remain to be determined.

§. 396. The ventricles seem to be made of necessary consequence, and towards the greater use and distinction of the parts. And that the corpora striata or thalami might keep their medullary parts from cohering one to another, it was necessary for a vapour to be poured betwixt

twixt them; and the same is true, with regard to the brain and cerebellum. Perhaps likewise the necessity of administering a degree of warmth to the close medulla of the brain may be one reason for these cavities, by which the arteries enter, and are distributed in great numbers.

§. 397. The uses of most of the protuberances we are not acquainted with, but have them yet to learn from diseases, and from anatomical experiments made on animals, having a brain like that of mankind. But, in these respects, we have little hopes of success, in parts that are so small, so deeply, and so difficultly situated, and hardly ever to be approached, but by a wound soon fatal. Whether these parts are so many distinct provinces, in which our ideas are stored up; and whether this be confirmed by the protuberant thalami of the optic nerve, are, indeed, questions. But then most of these protuberances send out no nerves at all.

§. 398. As to the internal communication of one part with the other by striæ or ducts; that seems to conduce to the advantage of motion, and probably of sense likewise. Some of these communications join the brain with the cerebellum, others join the spinal medulla with the nerves of the brain itself, as in the accessory nerve, and most of them join the right and left parts together, as in the anterior conjunction before-mentioned (§. 362.), and in the two posterior (§. 365.), in that of the corpus callosum (§. 360.), in the striæ, betwixt a process of the cerebellum and testes (§. 368.);

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to which add, the medullary cross-bars in the medulla oblongata and spinalis (§. 369.). For, from this structure, it seems manifestly to follow, as well as from numberless experiments and observations, that when the right side of the brain is injured, all the nerves, which belong on the contrary to the left side of the body, become diseased or paralytic, and the reverse. Moreover, by this contrivance, nature seems to have provided, that, in whatever part of the brain an injury may happen, the nerve, that arises from thence, is, by this means, not always deprived of its use. For if the said nerve receives its fibres by communicating bundles, as well from the opposite as from its own hemisphere of the brain, its office may, in some measure, be continued entire by the fibres, which it receives from the opposite side, even after those of its own side are destroyed. Accordingly we have numberless instances of wounds, and with a considerable loss of substance from the brain, which yet have not been followed with injury to any nerve, or to any of the mental faculties. [Many other less inequalities, stripes, protuberances, and nerve-like impressions appear in the brain from mechanical necessity, with the pulsation of the vessels, and the pressure or figure of the continuous incumbent parts.]

§. 399. Whether or no there are distinct provinces for the vital or spontaneous, and for the animal or voluntary actions? and whether the cerebellum furnishes the heart and other vital organs with nerves, while the brain supplies

plies the nerves, which go out to the organs of sense and voluntary motion? indeed, this, though an elegant system, is every where confuted by anatomy. From the cerebellum, the fifth nerve is manifestly produced; but then this goes to the tongue, to the pterygoide muscles, buccinators, temporals, frontals, muscles of the outer ear, of the eye, and of the nose, which are parts all of them either moved by the will, or else destined to sensation. Again, from one and the same nerve, as in the eighth pair, there are vital branches sent to the heart and lungs, and others that are animal and voluntary to the larynx, or sensitive in the stomach. Lastly, the repeated accounts of injuries to the cerebellum, being so suddenly and speedily fatal, are not altogether true; for that both wounds and scirrhusities of this part have been sustained without any fatality to the patient, may be affirmed by certain experience, our own not excepted. [Nor is the difference of the brain, having a softer and finer texture than the cerebellum, any thing very considerable. But why does the brain appear itself insensible, and never transmit any pressure upon it to the mind? for this plain reason, that all sense is transferred to the mind, through the tubular medulla of the brain, which being either compressed, or otherwise occluded, no impulsion on the mind, even from its own pressure, can be received into the intellect.]

§. 400. But if this elegant hypothesis (§. 399.) be not true, you will say, what is the cause of the perpetual motion in the heart, intestines
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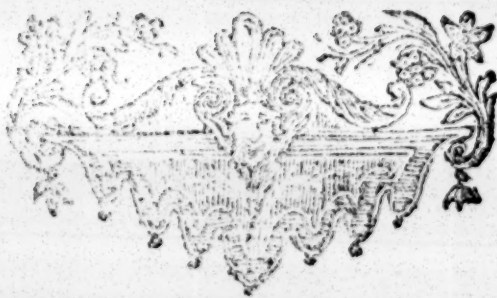
and other parts, which appear to want no inclination of the will to put them in motion and which, when in motion, are not governable by any power of the mind? why does the pulsation of the heart and arteries continue in an apoplexy after the nervous system is eclipsed, from whence all the voluntary motions or senses arise? indeed, the cause is so simple, as to be probably the occasion of its being almost universally overlooked. It is a general principle with nature in the animal fabric, for those organs to operate perpetually, which are most tender or irritable, which are most apt for motion, and which are, lastly, under a perpetual stimulus or irritation. The heart then is continually provoked to action by the venal blood, which it expels (§. 112, 115.). The same is also so easily and apt to be put in motion, that it may be recalled even after death; its muscular fabric is very solid and reticular, and its strength very considerable; from all which, therefore, it is extremely moveable, and its irritability appears more especially by the experiments before-mentioned (vid. §. 87.). Again the intestines also are extremely sensible; and, as will appear in their description, full of nerves, and from the circular position of their fibres apt to contraction, as we see in all parts that have such a disposition of their fibres. And besides this, they are almost perpetually irritated to motion, either by the chyle or aliments, by the confined air which they include, or by the bile sent from the liver; to which add the pressure of the hard fæces. With respect to

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the respiration, its perpetuity has been spoken of before, the alternation of which seems to me no otherwise explainable, than from the anxiety or uneasiness which follows both after inspiration and expiration, which call both for a speedy change. Vid. §. 293, 294, 298.

§. 401. We have before declared, that the nerves are the organs of sense and motion; we shall, therefore, proceed first to explain that motion before we describe the organs of sense; because it is more simple, uniform, and perpetually exercised, even in the foetus before any of the senses.



LECTURE XIII.

Of muscular motion.

§. 402. **B**Y the name of muscular fibres in the human body, we call bundles of reddish coloured threads, which, by an approximation of their extremities, perform all the motions of which we are sensible. When many of these fibres are collected together, and appear more evidently red, they are called a *muscle*. The extreme simplicity of the fabric in these parts has been the cause of the obscurity that prevails in understanding, how a small, soft, fleshy portion can produce such strong and ample motions as we see in man, but more especially in the crustaceous insects.

§. 403. In every muscle we meet with long soft threads or *fibres*, somewhat elastic or extensible, and almost constantly disposed parallel with each other; and these, being surrounded with a good deal of cellular substance, are by that fastened together into little bundles. Those bundles, called *lacertuli*, are again tied together into larger bundles, by a more loose cellular network, which contains some fat; and betwixt these we constantly perceive membranous partitions and stripes of the cellular substance, removing them farther from each other, 'till, at last, a number of them, combined together in a posture either parallel or inclined, are surrounded with a more thin and dense cellular

membrane, continuous with that of their partitions; and this being again surrounded by a thicker plate of the cellular substance, externally parts the whole from the adjacent flesh, and gives it the denomination of a single or entire muscle. In every one of these threads there appears a lesser series of filaments, which, by oblique extremities, are cemented to others of the same kind forming together a larger fibre.

§. 404. The generality of the muscles, but more especially those which are inserted into the bones, and such as are pressed strongly by other fleshy incumbent parts, do not consist of fibres altogether of one kind. For the fleshy fibres (§. 403.), being collected together, cause the muscle to be thicker in the middle, which is called its *belly*; and the same fibres, degenerating by degrees obliquely at each end of the muscle into a more slender, hard and shining substance of a silver colour, change the nature of flesh for that of tendon, in which, meeting closer together, the cellular substance interposed is thinner, shorter, and painted with fewer vessels; whence it passes under the denomination of a *tendon*, by being collected together into a round slender bundle; or else, if it expands into a broad flat surface, it is called an *aponeurosis*. For that the fleshy fibres truly change into such as are tendinous, is evident from comparing a foetus (in which there are very few tendons) with a child of some years growth, in which there are many more; and both with an adult or old person, in which are the

the greatest number. Muscles, which are not inserted into any of the bones, have commonly no tendons, as the sphincters and muscular membranes of the viscera and vessels. But those commonly end in long tendons, which are required to pass round the joints and heads of the bones, to be inserted in those extremities which are more moveable. In a foetus, the muscles are evidently inserted into the periosteum only; but in adults, where the periosteum is more closely joined and incorporated with the bone itself, the tendons, being confused with the periosteum, pass together with that even into the foveoli of the bone.

§. 405. Within the cellular substance or membrane that surrounds the fibres, the arteries and veins are subdivided into networks, which commonly form right angles, run in company, and mostly contiguous with each other; and from the smaller of these vessels a vapour is exhaled into the thinner cellular substance, as the fat is also transfused into the thicker cellular substance; from whence again they are both absorbed. The lymphatic vessels, which run betwixt the muscles of the tongue, with those of the neck, face and limbs, are difficultly demonstrated. But there are also nerves more numerous than in other parts, distributed together with the blood-vessels throughout the cellular fabric of the muscle; which nerves, however, deposite their harder covering, and become soft before they can be traced to their ultimate extremities in which they disappear. Those enter the muscle in many parts, with-

out keeping to the same place or situation; but in the tendons, they are very difficultly demonstrated. Nor are there any nervous fibres investing the muscular bundles or portions, so as to constrict them; for they, who have given such a description, have seen nothing but the cellular substance.

§. 406. The fabric of the least, which are as the elements of a muscle, being divestigated by the microscope in man and other animals, has always appeared similar to the fabric of the larger fibres; nor do they yield any other appearance, upon which we can rely, than that of the least threads joined one to the other by the intermediate cellular substance. There is, therefore, no foundation here for a series of vesicles, nor for a chain of rhombs. It may be asked, whether these fibres are hollow, whether they are continued with the arteries? or whether the difference betwixt muscular and tendinous fibres lies in the latter, being rendered more dense and beat closer together by an expulsion of the fluids? that these are not probable, appears from the minuteness of the fibres, which are found less than the red blood-globules, and from the whiteness of a muscle after the blood is washed out of it; to which add the physiological reasons following, (§. 411.).

§. 407. It is natural to every muscle to shorten itself, by drawing the extremities towards its belly or middle. But to discover the moving power of a muscle from the fabric, which we have described, it will be of use to consider the appearances, observable in muscular contraction.

traction. Every muscle then becomes shorter and broader in its action; but this contraction of its length is various, in some more, in others less, and is very considerable, for example, in some of the sphincters, insomuch that they appear to be contracted more than one third of their extent, though this computation be taken from an erroneous hypothesis. At the same time that the muscle is broader, it also becomes harder, and every way extended throughout its whole circumference; as for example, in the heart, in the masseters. Moreover, this motion in a living animal is made with a convulsive swiftness, while the fibres and muscular portions are drawn out of their simple rectilineal course into undulated wrinkles, which are formed as well in the elementary simple fibres, as in the more compound lacertuli or bundles; wherefore the motion of every muscle lies in a retraction of the fibres within themselves, which being alternately more or less contracted, increase or diminish the length and breadth of any interval betwixt the points of contraction. I observe also, that the larger muscular portions themselves are drawn out of their course, so as to form different angles with each other, and with the bones which they move; and in general, right angles are changed into such as are unequal; but that the muscles grow pale in their action, does not appear in all my experiments.

§. 408. Moreover, that we may discover the cause of muscular motion, we are to observe, that in every muscular fibre, even after death,

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there is a force or endeavouring to contract its length, by which, being left to itself, it becomes shorter; and from hence, muscles, that are divided even in a dead body, recede by contracting from each other, so as to leave a considerable interval. [Again, the parts of a moving fibre, being agitated or *irritated* by any force, which we call a stimulus, whether cold, puncture with the knife, acrid poisons, &c. does immediately exert a vital corrugation, or contraction, different from the former dead one, of elasticity, so long as the vital or locomotive, but unknown, disposition of its parts remains, even after death; by which irritation, we observe, it will palpitate for a time, by alternately corrugating and elongating itself. This faculty of irritability is never observed to reside in any part of the cellular substance; nor in membranes, so far as they are, in a great measure, composed out of that substance; in ligaments it is scarce observable in any degree, and in tendons it is extremely weak: but in muscles, more especially those of the heart and intestines, it resides in a most remarkable degree, so as to be susceptible of irritation and contraction longer than in any other parts of the dying animal, and even for many hours after death; and in these parts too, the action is more violent in proportion, as the faculty or power longer remains, and is more easily excited than in other parts. It must be also confessed, that the evulsion of a muscular irritable part out of the animal body, so as to cut off all union with its nerves, and intercept all intercourse betwixt itself

self and the brain, does not much abate the irritable faculty and contractile force of the part, more especially in the heart and intestines. That this irritable power of corrugation or contraction prevails largely, throughout all the animal fibres that are motive, appears plainly from the observations made upon the polype and other simular insects; which, being formed without either brain or nerves, are nevertheless extremely motive and impatient of all stimulus. Add to these, shell-fish and the analogy of some plants, whose flowers and leaves move their places, by expanding or contracting with heat or cold, and some of them with a sort of sensative celerity, not inferior to that of animals. This force is, therefore, a new and hitherto neglected principle, different from the other known properties of bodies, and is not like them to be accounted for, either by gravity, attraction, or elasticity; but depends upon an unknown disposition of the parts in a soft moving fibre, which looses this force as it hardens and dries. See remark to §. 6.]

§. 409. But that the cause of motion is conveyed through the nerves into the muscles, is certain from the experiments before-mentioned (§ 378.). Namely, a nerve or the spinal medulla, being irritated in an animal, even soon after death, the muscle or muscles, which are supplied in branches from that nerve, become languid or paralytic, so as not to be able to move or to be recalled by any force to vital action. But if the ligature be taken off from the nerve, the force, by which the muscle is
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put into action, is again recovered by it. This appears from numerous experiments, more especially upon such as have been made upon the phrenic and recurrent nerves. Also by irritating any nerve before you cut it, the muscle, to which it goes, contracts, as you may learn by repeated trials, easily to be made on the limbs or extremities. Moreover, the weight, which is raised by a living muscle, breaks or tears one that is dead; whence it appears to be greater than the inherent cause of contraction in a muscle, by which, when living, the weight was raised.

§. 410. If it be demanded, whether the arteries conduce any thing to muscular motion? and whether the palsy, which falls upon the lower limbs, after a ligature upon the aorta, be not an argument thereof? we answer, not at all, further than as they conduce to the integrity of a muscle or to the conservation of the mutual structure and habit of the parts, which they supply with vapour, fat, &c. for the irritation of an artery does not affect or convulse the muscle to which it belongs, nor does a ligature thereof cause a palsy, unless after a considerable time, when the muscles begin to be destroyed by a gangrene; and the palsy of the lower limbs from a ligature of the aorta belongs to an injury or loss of the integrity of the spinal medulla. Moreover, it is impracticable to explain the motion of peculiar muscles from a cause derived with an equal force from the heart to all parts of the body; and again, the influence of the will is confined to the nerves, with-

without residing in the arteries or other solid parts of the body.

§. 411. But the direct manner, by which the nerves excite motion in the muscles, is so obscure, that we may almost for ever despair of its discovery. As to nervous vesicles swelling by a quicker flux of the nervous spirits, they are inconsistent with anatomical truth, which demonstrates the least visible fibres to be cylindrical, and in no part vesicular, and likewise repugnant to the celerity with which muscular motion is performed, and with the bulk of a muscle being rather diminished than increased during its action. Again, the inflation of rhomboidal chains in the fibres is equally repugnant both to the celerity, to inspection, and to anatomy. Finally, it is, by no means, demonstrable, that the fibres, from so few nerves, can be so numerous, or distributed in so many different transverse directions, with respect to the muscular threads, as those hypotheses require to be allowed. A complication of the nerves round the extremities or fibres, so as to contract them by their elasticity, is founded upon a false structure of the muscular fibre, supposing the nerves to be distributed, where filaments of the cellular substance only can be demonstrated. [Moreover, the experiments on animals (§. 488.), which, having neither brain or nerves, are yet very apt for motion, apparently demonstrate the intrinsic fabric of the muscles to be sufficient for their motion, without other assistance from the nerves.] Other explanations, derived from spherules full of air
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in the blood, suppose a false nature of that fluid; namely, a repletion of it with elastic air, of which it has none, (§. 306.)

§. 412 This only we are certain of, from what has been advanced, that the nerves act not by their mechanical contraction, which is extremely weak, but by the power of an influent liquid, detached, or some way actuated, with great celerity. That muscle, therefore, will be contracted, to which more nervous liquid arrives in a given time, whether that be from any impulse of the will or other cause residing in the brain, or else from the power of some stimulus in the nerve itself. [Now whether the nervous liquid only increases the irritable nature, or else augments barely the inherent corrugating force of the constituent parts in the moving fibre, after a manner unknown to us, we see, in either case, that the consequence is a shortening of the fibre or muscle.] More than this, I am not able to perceive. The same muscle is again relaxed, when this additional celerity in the motion of the nervous fluid is abated, and sends it only in such a quantity as will make an equilibrium.

§ 413. The effect of motion in the muscles is a contraction or shortening of them, by drawing their tendons almost quiescent each way towards their middle or fleshy belly, by which means the bones and other parts, in which the tendons are inserted, are brought together in the same manner as when a muscle cut out of the body, contracts or draws its two extremities towards the middle part or belly.

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But if one of these extremities be less moveable or more fixed; then, that which is more moveable has a greater motion towards that which is more fixed, in a proportion inversely as their mobility. If one end be immoveable, then the other, which is moveable, is alone brought towards it; and, in this sense, the distinction of origin and insertion of the muscles is allowable; otherwise, without this limitation, it may be frequently the cause of error.

§. 414. The strength of this action in the muscles is very considerable in all persons, but more especially in those who are phrenetic, and some who are called strong men; since frequently, with the use of a few muscles only, they will easily raise a weight equal to, or much greater than, that of the whole human body itself. Notwithstanding this, we see, that much the greater part of the force or power, exerted by a muscle, is always lost without producing any visible effect. For all the muscles are inserted nearer the point or center of motion, than the weights they are applied to; and therefore their action is weaker, in the same proportion, as they move a shorter part of the lever, than that to which the weight is applied. Moreover, in most of the bones, especially those of the limbs, the muscles are inserted at very acute angles; whence again the effect, which a muscle exerts in action, is proportionably less, as the sine of the angle, intercepted betwixt the bone and the muscle, is less than the whole sine. Again, the middle part of all muscular force is lost, because it
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may be reckoned as a cord extended, and drawing an opposite weight to its fixed point. Again, many of the muscles are seated in the angle of two bones, from one of which arising they move the other; and, therefore, that bone being moved, they are bent, and, of course, like an inflected cord, require a new force to extend them. Many of them pass over certain joints, each of which they bend in some degree, whereby a less part of their remaining force goes to bend the joint to which they are particularly destined. The fleshy fibres themselves of the muscles frequently intercept angles with the tendon, in which they terminate; from whence a great part of their force is lost, as much as is equal to the difference or deviation betwixt the sine of the angle of their insertion and the whole sine. Finally, the muscles move their opposed weights with the greatest velocity and expedition, so as not only to overcome the equilibrium, but likewise to add a considerable celerity to the weight.

§. 415. All these losses of power being computed, make it evident, that the force, exerted by muscles in their contraction, is exceeding great beyond any mechanical ratio or proportion whatever; since the effect is scarce $\frac{1}{6}$ of the whole force exerted by the muscle, and yet only a small number of these muscles, weighing but a few pounds, are able not only to raise some thousands of pounds, but also with a considerable celerity. Nor is this to be reputed any defect of wisdom in the creator.

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For all those losses of power were necessary towards a just symmetry or proportion of the parts, with the various motions and celerities required by the muscles to act in different directions; all which have no share in the composition of engines mechanically. But we may, however, conclude from hence, that the action of the nervous or animal fluid is very powerful (§. 392.), since, in an engine so small, it can exert a force equal to some thousand pounds for a considerable time, or even for many days together; nor does this seem to be otherwise explainable, than by the incredible celerity by which the influx of this fluid obeys the command of the will. But how, or from whence, it acquires such a velocity, is not in our power to say; 'tis sufficient, that we know the laws of its motion are such, that a given action of the will produces a new and determinate celerity in the nervous fluid or juice.

§. 416. The easy and sudden relaxations of muscles in their motion are assisted by the actions of their *antagonist* muscles. Namely, in all parts of the body every muscle is counterpoised by some weight, elasticity, an opposite muscle or a humour acting against the cavity of a muscle, by which it is expelled. This opposite cause, which ever it be, continually operates as long as the muscle acts, and, so soon as the additional celerity, derived from the brain, abates, it restores the limb or other part immediately to its former easy state, in which there is an equilibrium betwixt the muscle and its opposing cause. Whenever the antagonist power is removed

moved from the muscle, there are none of them but must contract, extending their opposites, by which the distended nerves excite an uneasy sense, and cause a stronger endeavour towards recovering the equilibrium. Hence one of the flexor muscles, being cut in two, the extensor contracts or operates even in a dead body, and the reverse.

§. 417. But there are other means, by which the motions of the muscles are rendered more safe, certain and easy. The large long muscles, by which the greater motions of flexure are performed, being included in tendinous capsules or cases, drawn and tightened by other muscles, are thus secured and strengthened; for so the muscle remains pressed against the bone, in a state of contraction, all the time that the limb is bent, and avoids a considerable loss of its power. But the long tendons, which are incurvated or extended over joints in their motion, are received and confined by peculiar bands, which retain them within their slippery channels, and keep them from slipping out under the skin, which dislocation of the tendon, whenever it happens, is attended with a cramp of the muscle, severe pain and loss of motion. The same kind of guidance or direction is received by some of the muscles, which perforate others in their course. In other parts, the tendons are either carried round certain eminencies of the bone, in order that they may be inserted at greater angles into the bone, which they move, or else they are inserted into another bone; from whence a dif-

herent tendon descends under a larger angle into the bone to be moved. In other parts, the muscles, which are derived from convenient situations, have their tendons carried round in a contrary direction by nature, so that they pass into the part to be moved, as it were round a pulley. Nature has likewise surrounded the muscles on all sides with fat, which is spread also betwixt their bundles of fibres and the small fibres themselves which lie contiguous together; which fat, being pressed out by the turgescence of the muscles and fibres, renders them soft, flexible, slippery, and fit for motion.

§. 418. Moreover, the power and action of one muscle is determined by the co-operations or oppositions of others, which serve either to hold firm some part from whence the muscle arises, or to bend it together with the muscle, or else to change its action from the perpendicular to the diagonal, by concurring to assist its force at the same time. Therefore, the action of no one muscle can be understood from considering it alone, but all the others must likewise be brought into the consideration, which are either inserted into the muscle itself, or into any of the parts to which the said muscle adheres.

§. 419. By these muscles, variously conspiring and opposing each other, are performed walking, standing, flexion, extension, deglutition, and all the other gestures and offices of the several parts in the living body. But the muscles have likewise some common or public actions, by which they are of use to the whole

an mal. They hasten the return of the venal blood, by pressing it out from the veins, both of the muscles themselves as well as of the veins which lie betwixt them; for the blood in these vessels, distributed betwixt the turgid bundles of a contracted muscle, is, by the valves, determined towards the heart only; they likewise return the fat to the blood, shake, grind, or densify the arterial blood, and return it quicker to the lungs. Again, in the liver, mesentery womb, &c. they promote the course of the contained blood, bile and other juices, so as to lessen the danger of their stagnation; they serve also to increase the strength of the stomach, by adding their own strength to it, whereby digestion is promoted, insomuch that all sedentary and inactive courses of life are contrary to nature, and pave the way to diseases from a stagnation of the humours, or from a corruption or crudity of the aliments. But by too much exercise or action, the muscles themselves grow hard and tendinous on all sides, render the parts, upon which they are incumbent, cartilaginous, or else change those, which are membranous, into a bony nature; at the same time they increase the roughness, protuberances and processes of the bones, flatten their sides which lie next to them, and dilate the cells seated in the diploe or spongy heads of the bones themselves towards their stronger action.

§. 420. The muscles are commonly distinguished into classes, according as they either rest spontaneously, or are put into action by an incli-

inclination of the will; whence they are called voluntary and involuntary, while others are mixed. Some of them operate spontaneously, and can neither be excited nor retarded by the will, as in the heart and intestines; and some again are subservient to a mixed power, as they operate by a spontaneous motion, and are likewise governable by the will at the same time, as in the muscles of respiration. There have been various causes assigned for this difference; but I think the question has been sufficiently answered before at §. 400.

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